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SYMPOSIUM ON INVESTIGATIONS AND RESOURCES OF THE CARIBBEAN SEA AND ADJACENT REGIONS

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Willemstad, Curaçao
18-26 November 1968

Report and Abstracts of Papers

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ROME, 1969

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SYMPOSIUM ON INVESTIGATIONS AND RESOURCES OF THE CARIBBEAN SEA AND ADJACENT REGIONS

Preparatory to the

Cooperative Investigation in the Caribbean and Adjacent Regions (CICAR)

Organized through the joint efforts of FAO and UNESCO

Willemstad, Curaçao, Netherlands Antilles

18 - 26 November 1968

Report and abstracts of papers

Edited by

Marine Biology and Environment Branch
Fishery Resources and Exploitation Division
FAO, Rome

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, December 1969

EDITORIAL NOTE

This publication forms part of the Proceedings of the Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions organized jointly by UNESCO and FAO and co-sponsored by WMO, held in Willemstad, Curaçao, from 18 to 26 November 1968. The symposium was preparatory to the Cooperative Investigations in the Caribbean and Adjacent Regions (CICAR) which will start in 1970 under the aegis of the Intergovernmental Oceanographic Commission. The present volume, issued by FAO in its FAO Fisheries Reports series, contains the report and abstracts of papers contributed to the symposium. The material in it was compiled and edited G. Saetersdal, Acting Chief, Marine Biology and Environment Branch, Fishery Resources and Exploitation Division, with the assistance of the Office of Oceanography of UNESCO. The full texts in their original language of the papers contributed to the Fishery Resources Section of the Symposium will be issued by FAO in the same series. The integral texts of the contributions to the Symposium sections on Physical and Chemical Oceanography, Marine Geology and Geophysics and Marine Biology, will be published by UNESCO. The views expressed in this report and in the contributed papers are those of the authors and do not necessarily reflect the policies of the sponsoring agencies.

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ASW. Physical and chemical oceanography. Marine geology and geophysics. Marine biology. Fishery resources. Review of research and exploitation. Recommendations. List of participants.

CONTENTS

		Page
GENERAL REPORT		
1.	Introduction	1
2.	Opening Session	1
3.	Officers and Organization of Work	2
	3.1 Officers of the Symposium	2
	3.2 Organization of Work	2
4.	Sectional Reports and Recommendations for CICAR	2
	4.1 Report of Section I - Physical and Chemical Oceanography	2
	4.2 Report of Section II - Marine Geology and Geophysics	6
	4.3 Report of Section III - Marine Biology	11
	4.4 Report of Section IV - Fishery Resources	13
ANNEX 1.	List of Participants	21
ANNEX 2.	Addresses at the Opening Session	31
ANNEX 3.	Introductory Lecture. A Review of Research and Exploration in the Caribbean Sea and Adjacent Waters, by Frederick M. Bayer	41
ANNEX 4.	Author Index and Titles of Papers	93
ANNEX 5.	Abstracts of Papers	101

1. INTRODUCTION

During its fifth Session in 1967, the Intergovernmental Oceanographic Commission adopted a proposal forwarded through the initiative of the Netherlands Delegation for a Cooperative Investigation in the Caribbean Sea and Adjacent Regions (CICAR) to be conducted from 1970 onwards. In order to facilitate the planning of the scientific programme for CICAR, it was decided to organize a "Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions" under the joint sponsorship of the United Nations Educational Scientific and Cultural Organization and the Food and Agriculture Organization. Later on, the World Meteorological Organization decided also to act as co-sponsor. The purpose of the Symposium was defined as follows: To review knowledge and to identify existing gaps in the field of scientific investigations and of resources research in order to improve scientific cooperation and rational use of marine resources in the Caribbean Sea, the Gulf of Mexico and Adjacent Regions of the Atlantic Ocean as well as to facilitate the planning of CICAR. The contributions of the sponsoring organizations were:

UNESCO: Secretarial services, travel expenses and subsistence for certain invited participants. Publication of volume of proceedings containing contributions on physical and chemical oceanography, marine geology and geophysics and marine biology.

FAO: Secretarial services, travel expenses and subsistence for certain invited participants, publication of volume of proceedings containing Abstracts of Papers and the Report of the Meeting, and contributions on fishery resources.

WMO: Sponsorship of certain lectures.

Local arrangements including administrative secretarial services were provided by the Government of the Netherlands and the Government of the Netherlands Antilles.

2. OPENING SESSION

Admiral W. Langeraar, Chairman, Intergovernmental Oceanographic Commission, opened the session and introduced the speakers.

Dr. G. Giermann addressed the meeting on behalf of the Director-General of UNESCO, followed by Dr. M. Ruivo on behalf of the Director-General of FAO and Dr. A. Bruinenberg on behalf of the Secretary-General of WMO (see Annex 2).

Dr. N. Debrot, Governor of the Netherlands Antilles welcomed participants on behalf of the Government and people of the Netherlands Antilles. He briefly reviewed the history of modern science stressing that its basic significance in our time lies in the programmatic employment of service to mankind and especially to the countries and people in the stage of development. The pragmatic trend of our science is obvious in oceanographic research. The three specialized agencies under whose auspices the Symposium takes place all pursue practical purposes basing their work on a scientific foundation.

The Governor thought that this Symposium would be of significance for research that can lead to the tapping of new resources in the Caribbean and its surroundings with the aim to help alleviate and solve the food problem in the region itself. Seeing the Symposium as an effort to help uncover the secrets of the ocean the Governor welcomed it and wished it every success.

An introductory lecture (see Annex 4) entitled "An Historical Survey of Marine Research in the Caribbean Area" was then delivered by Professor Frederick M. Bayer.

3. OFFICERS AND ORGANIZATION OF WORK

3.1 Officers of the Symposium

President: Rear Admiral W. Langeraar

	Conveners	Rapporteurs
Section I - Oceanography	Dr. I. Emilsson	Dr. R. Davila Cuevas Dr. F. Ostapoff Dr. L.V. Worthington
Section II - Marine Geology	Dr. H.J. MacGillavry	Dr. T.W. Donnelly Dr. C. Schubert
Section III - Marine Biology	Dr. A. Ballester	Dr. L. Hammer Dr. L. Howell-Rivero
Section IV- Fishery Resources	Dr. C. Idyll	Dr. G.L. Kesteven Prof. J.L. Cifuentes

Symposium Rapporteurs	Scientific Secretariat
Dr. H. Barrales, UNESCO Mr. G. Saetersdal, FAO	Dr. G. Giermann, UNESCO Dr. M. Ruivo, FAO

Chairman, Local Organizing Committee

Dr. F. Creutzberg

3.2 Organization of Work

The Symposium was arranged in four sections:

(i) Physical and Chemical Oceanography and related meteorology

(ii) Marine Geology and Geophysics

(iii) Marine Biology

(iv) Fishery Resources

Twenty-five invited lecturers were asked to present review papers in the fields listed above. In addition, contributions were invited from scientists working in the area and these contributed papers totalled 114.

Discussions were held after each session. On the last day of the Symposium a final discussion took place on the identification of research needs and the adoption of recommendations for CICAR. All meetings of the Symposium were considered as Plenary Sessions.

The Symposium was immediately followed by the first meeting of the International Coordination Group for Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR) on November 25 and 26. The reports and recommendations of the various sections of the Symposium were made available to this Meeting.

4. SECTIONAL REPORTS AND RECOMMENDATIONS FOR CICAR

4.1 Report of Section I - Physical and Chemical Oceanography

The papers read in this section dealt with the general circulation of the Caribbean Sea and some of its adjacent regions, some more detailed investigations of small areas in the Caribbean Sea and with coastal and continental shelf oceanography.

General Circulation

Among the papers presented one dealt with an undercurrent, similar in structure to the Cromwell Current in the equatorial Atlantic. This undercurrent was found, by the dynamic method, flowing towards the east in the opposite direction to the main westerly flow through the Caribbean. A number of oceanographic sections, widely separated in time, showed that this was not merely a transient phenomenon.

In the general circulation of the Caribbean Sea it was shown that numerous authors agree, that approximately 30 million m^3 sec pass through the sea from east to west, but that a contradiction existed between two classical techniques of physical oceanography: dynamic computations show that by far the greater part of this transport should take place in the southern third of the Caribbean Sea, but water mass analysis shows that the water leaving the Caribbean through the Florida Straits is deficient in Antarctic Intermediate water which is the most abundant water mass in the southern Caribbean. The water leaving the Caribbean has the temperature and salinity characteristics of western North Atlantic water except in the upper 100 m. It means that direct current measurements are needed to resolve this dilemma.

A group of fixed hydrographic stations around the island of Cuba has been established to study the oceanographic environment of the island. These will be occupied at regular intervals. Some of the preliminary results show interesting variations in the concentration of salinity in the salinity maximum layer. Rapid changes in the position of the Florida Current off Habana were related to changes in the wind field.

The effect of bottom topography, specifically that of the Jamaica Rise, was adduced to account for irregularities in the circulation of the upper layers of the Cayman Sea. It was further proposed that the extremely high current velocity on the western side of the Yucatan Channel could be attributed to the conservation of potential vorticity.

Attention was also drawn to discontinuities in the physical and chemical characteristics of the deep waters of the Atlantic and Caribbean, both at sill depth and above sill depth. It was proposed that the deeper sources of Caribbean water are inactive at the present time.

Detailed investigations of smaller areas

Two independent studies were presented of the water to the east of the Grenadine Islands, immediately outside the southern Caribbean. In one of these dynamic computations, supported in part by direct current measurements, indicated that 80 per cent of the water which enters the Caribbean through the passages between the southern Antilles also passes between the islands of Barbados and Tobago. In the other, two closely knit networks of hydrographic stations showed that the waters to the east of the Grenadines vary widely in transport and, particularly, in direction; of two quasi - synoptic surveys, one indicated a western flow, compatible with the Barbados - Tobago section already mentioned, and the other indicated almost entirely northerly flow.

A very detailed examination of the Jungfern or Virgin Islands Passage was of great interest. It was shown that above the threshold or sill which provides the deepest access to the Venezuelan Basin, water could be found of considerably greater density than that of the abyssal waters within the basin. It is difficult to understand why this dense water is not at present cascading into the basin but the evidence that it is not seems unequivocal.

Shallow and coastal oceanography

A considerable area of shelf with a mean depth of 5-15 m exists in two separated areas off the south coast of Cuba. The water characteristic particularly temperature and salinity, vary to an increasing extent in proportion to their distance from the parent deep water. The probability that winter cascading of shelf water off the Cuban shelf was proposed. A preliminary but promising investigation which has been initiated on the much smaller Puerto Rican shelf was discussed.

Among the topics covered in the discussion were the desirability of direct current measurements in the passages between the Antilles. It was further suggested that intercomparison of techniques be undertaken before any large scale oceanographic expeditions are made in the Caribbean. It was further noted that the Key West - Habana cable showed large variations in the Florida Current Transport but that direct measurements of the Florida Current further north, off Miami, showed no such variation.

The importance of investigating oceanographic variation of different time scales was stressed.

Hurricanes and air-sea interaction

The topic of both sections concentrated mainly on the severity of hurricanes and tropical disturbances and their effects on the ocean.

Three review lectures were presented in these sections. They dealt with the atmospheric structure of the hurricanes, statistics of hurricanes and tropical storm distributions as function of time and various geographical locations with respect to the Caribbean Sea and Adjacent Regions.

Hurricanes effects were discussed extensively on shore lines in context of their distructive forces due to storm surges.

Finally considerable observational material was presented concerning the effects of hurricanes on the underlying water column. The most documented case, hurricane HILDA, was discussed at great length.

From all the presentations, including some observations by means of infra-red radiometers flown by aircraft over water subjected to hurricanes passages, it is concluded that the hurricanes leave a temperature signature on the sea surface. Whether mostly due to upwelling or direct heat loss due to sensible and latent heat exchange is not clearly established. Probably both processes are significant enough to produce the lower temperatures in the wake of these storms.

Two main points held the attention of the Symposium and led to extensive discussions:

- the effects of hurricanes on shore lines, in particular the difference in storm surges between gently rising shelfs with flat coastal areas and steep shores.

- the effect of hurricanes in producing upwelling and down-welling.

Another paper dealt with numerical modelling of hurricanes. Difficulties were exposed in that the interaction between the hurricanes and its environment is still poorly understood, hampering progress in prediction of hurricanes movements.

From the intense discussion of the storm surge aspects of hurricanes it was recommended that, a network of tide gauge stations, carefully exposed, should be installed around the Caribbean Sea.

The Caribbean Sea may be a suitable area to study effects of upwelling and energy budgets associated with tropical storms. New technology, such as meteorological satellites and oceanographically instrumented aircraft may provide new insight into strong interactions.

Sound propagation

One paper was presented under this headline. It dealt with observations of sound velocity in Venezuelan coastal waters. The horizontal distribution of this factor was demonstrated. It is recommended that this work shall be continued and that it shall be extended to other areas.

Chemistry

The chemical and hydrographical characteristics of the Cariaco Trench, in particular the formation of anoxic systems, was examined.

The following topics were dealt with:

a) The vertical distributions of the various nitrogen form (inorganic and organic) where a minimum value appears between the depth of 300 and 400 m.

b) High carbon and organic nitrogen values were observed in sediment nodules from the Cariaco Trench.

c) The vertical distribution of hydrocarbons, methane and free nitrogen, show high values in the anoxic water. The mechanism governing the formation of hydrocarbonates was also discussed.

d) The relation between dissolved oxygen and the vertical distribution of different forms of inorganic nitrogen was considered.

e) The feasibility to define water masses by means of the vertical distribution of the strontium/chlorinity ratio was considered. The influence that biomass might have on the observed variation of the strontium/chlorinity ratio was discussed.

f) The distribution of barium was presented.

Identification of Problems and Recommendations for Approach

General circulation and water masses

(a) Identification of basic problems

(i) Inflow and outflow at different levels through the passageways and relation with the adjacent water bodies.

(ii) Upwelling and sinking in relation to the wind field; seasonal and longterm variation.

(iii) The renewal of the water below the sill depth in the different basins of the region.

(iv) Circulation and mixing of water masses within the region.

(v) Effects of tropical cyclones and of the passage of cold fronts on the water structure and circulation.

(b) Recommendations for approach

(i) General oceanographic surveys, coordinated in time and space, with special attention to the summer season.

(ii) Special surveys by means of vessels, airplanes, satellites and buoys, during the main season of hurricanes (August, September, October) and the "northers" (November to January).

(iii) Regular sampling of temperature and salinity data from the upper layer (about 200 m) by means of commercial vessels.

(iv) Data sampling at fixed positions or along fixed lines conveniently located in the region.

(v) Simultaneous current measurements in the passageways by means of fixed current recorders, drogues and floats.

(vi) The use of existing submarine cables for G.E.K. recordings.

(vii) Sea level recordings by means of a net of tidal stations giving special attention to the passageways.

(viii) Transparency and optical studies and determination of sediment load for identification of water masses.

(ix) Intercalibration of instruments.

(x) Adequate communication means between cooperating vessels and stations as well as coordinating centres, where necessary and practicable.

Air-sea exchanges and hurricanes

(a) Identification of problems

(i) The heat budget of the region and its effect on surface temperature.

(ii) The evaporation-precipitation balance and its effect on surface salinity.

(iii) Sea surface temperature and its possible effects upon rainfall in different parts of the region.

(iv) Development and track of hurricanes in relation to oceanographic conditions.

(v) The effect of artificial surface films upon the development of a hurricane as well as upon the energy and mass transfer across the air-sea interface.

(b) Recommendations for approach

(i) Direct and indirect observation of evaporation at representative points in the region.

(ii) Improved observations of rainfall over sea areas.

(iii) Recording of radiation on land and on ships, including merchant vessels.

(iv) Experimental application of evaporation inhibitive films over areas approached by a hurricane.

(v) Regular observation of water discharge in strategically located rivers.

Chemistry

(a) Identification of problems

(i) Nutrient salts and trace constituents distribution in relation to primary production and other biological processes as well as to terrigenous factors (e.g. continental run-off) and oceanographical parameters.

(ii) The cation/chlorinity ratio and injected contaminants, such as radio nucleids, as a possible means to detect the origin and pathways of water masses.

(iii) The chemistry of the Cariaco Trench and other isolated basins, and its comparison with that of the adjacent sea.

(b) Recommendations for approach

(i) General oceanographic surveys, same as under "General Circulation and Water Masses" (b)(i) above.

(ii) Standardization of methods and inter-calibration of instruments. Training of personnel where necessary.

(iii) Regular sampling, fixed positions, etc. same as under "General Circulation and Water Masses" (b)(i) above.

4.2 Report of Section II - Marine Geology and Geophysics

4.2.1 Introduction

The Caribbean and adjacent regions occupy a crucial position with respect to two of the most important problems of contemporary earth science: continental drift and ocean-continental interaction (including especially sea-floor spreading). The Caribbean is a geologically active area caught between the evidently moving crustal plates of the East Pacific and West Atlantic Oceans. Its position between the major continents of the Americas give it an equally important bearing on the major question of past drift between these two areas.

4.2.2 Summary of lectures

In general, most papers presented in this section were of a descriptive nature. Several review papers, such as those by MAC GILLAVRY, MALONEY, DONNELLY and HESS, raised questions and problems about the geology and geophysics of the Caribbean region. These papers were of a general nature and point out gaps in the knowledge about this region. HESS emphasized the importance of the gravity expeditions at sea initiated by VENING MEINESZ, and the importance of his discovery of the negative anomaly belt.

Paper of interest in relation to the resources (one of the major themes of this Symposium) or of economic interest were generally lacking. Only ARDEN's paper on the exploration for petroleum in the Caribbean was specifically oriented in this direction.

Finally, it should be pointed out that most of the major oceanographical institutions (especially those from the U.S.A. and U.S.S.R.) were not represented, as they should have for a meeting of this nature.

4.2.3 Activities

Groups presently active

Two Russian ships (LOMONOSSOV, ACADEMICIAN KOVALEVSKY) are primarily engaged in biological studies, but are also carrying out marine geological studies.

Several U.S. groups are active. The U.S. Naval Oceanographic Office is operating the USNS KANE, a ship engaged primarily in reflection seismic work, but also doing coring and other oceanographic work. ESSA is operating the DISCOVERER along the northern coast of Venezuela and in the southern Lesser Antilles. Several U.S. universities and other groups (notably Lamont Geological Observatory, Woods Hole, University of Rhode Island, University of Miami, Texas A & M University, Duke University) are very active.

The Bedford Institute of Canada has conducted projects in the eastern Caribbean.

The Universidad Oriental of Cumaná, Venezuela, is actively studying the shelf area of that country.

They have also worked (together with Bedford) in the vicinity of Aves Island.

Groups planning projects

a) A group from the Netherlands anticipates several geological and geophysical projects, especially in the southern Caribbean.

b) A British ship will survey an area across the Lesser Antilles, probably north of the area currently being studied by the U.S.A., ESSA.

Topics of special current interest:

c) Reflection seismology; especially U.S. Naval Oceanographic Office.

d) Gravity; especially Lamont, Woods Hole, Vening Meinesz Laboratory of Utrecht.

e) Refraction seismology; approximately a hundred profiles, several unpublished, summarized by EDGAR of Lamont. No outstanding current activity.

f) Magnetics; aeromagnetic data of U.S. Naval Oceanographic Office (project MAGNET) being analyzed by DONNELLY. Sea magnetic data extensive, but not easily analyzed. These data are being studied by REMARD at Lamont. An aeromagnetic survey of the Nicaragua Rise has been made for several oil companies. The Jamaica Government has the map.

g) Sediment coring; several groups are active here; Lamont has well over a hundred largely unstudied cores from this area.

h) Heat-flow; Lamont is summarizing present data, which are lamentably sparse.

i) JOIDES; the project has completed three holes in the Gulf of Mexico and several more in adjacent Atlantic. Further drilling will be undertaken later.

j) Shelf morphology and sediments; the group from Venezuela is especially active here. Various smaller groups are active in the Netherlands Antilles. The Government of Trinidad and Tobago has commissioned a survey of the area between Trinidad and Tobago. The U.S. Geological Survey is active in Mona Passage and will extend its studies around Puerto Rico.

k) Petroleum companies; the Nicaragua Rise from Honduras - Nicaragua to Jamaica is currently under study by several companies. Almost the entire shallow water area is under concession to oil companies, and off-shore drilling is being undertaken.

l) Land activities; although not properly a direct part of CICAR, we should note that almost the entire land area around the Caribbean is being investigated currently, mainly by university groups, governmental agencies, and oil and mineral companies. Areas of great interest but only limited present study include most of southern Central America, much of Northern Colombia, the northern most Lesser Antilles, and much of Hispañola. No information about Cuban activities was made available at this meeting.

Identification of Research Gaps and Recommendations to CICAR

Greatest needs

(a) Accurate position fixing aids (e.g. satellite navigation)

(b) Nature of crustal material in basins

There are substantial reasons for thinking that the major basins of the Caribbean are basically oceanic, though modified. A major aim of this project should be to elucidate these differences. Determination of the age and origin of these areas would be the principal goal.

(c) Nature of submarine ridges

The problem of the nature of the ridges separating the basins (Cayman Ridge, Nicaragua Rise, Beata Ridge, Aves Swell) is inextricably linked with the previous problem.

(d) Deep structure of island-arcs

The study of deep structure of the island-arcs will be fundamental to an understanding of the tectonics of the ocean-Caribbean junction.

Recommendation for immediate action

(a) Data census

An important preliminary step should be taking a country-wise census and evaluation of data which already exist. This applies to geophysical, geological data, cores already taken, etc.

(b) Central bureau

A central bureau is to be established for the preparatory phase and for the duration:

(i) For the collecting and deposition of reference data, coordination of efforts and dissemination of information. Country-wise assembled data are deposited and coordinated here. Oil-company data available for the asking are to be actively solicited and consulted.

(ii) For establishing a reference library (on microfilm?) (in cooperation with Puerto Rico Center).

(iii) To obtain geological field data of importance to the interpretation of oceanographic and geophysical results.

(iv) To serve in an advisory capacity and to be alerted about activities of importance for additional operations, such as wells being drilled (rush in with heat flow, velocity survey apparatus), quarries blasted, etc.

(v) To suggest new areas or methods of investigation on the basis of results as they come in.

Projects of a cooperative nature

(a) Geo-traverse of Caribbean

The recent great success of a dominantly geophysical traverse across the U.S.A. (being extended now eastward to Africa) suggests a similar project from the Atlantic Ocean to the Pacific, crossing the Lesser Antillean Arc, the Venezuela Basin and Costa Rica or Panama. A branch could profitably be

extended northwestward across the Nicaragua Rise, Cayman Trough, and Yucatan Basin. This project should combine seismic refraction and reflection, gravity, and magnetic surveying, with heat-flow, dredging, and, hopefully, deep sediment coring.

(b) Island Arc deep structure survey

One (or more) long seismic refraction surveys parallel to the area of the Lesser Antillean and eastern Greater Antillean Arcs would be of inestimable benefit. Such a survey would involve facilities (mainly but not exclusively ships) of at least three major institutions.

(c) Bathymetry

Bathymetric results should be made available as soon as possible to the International Hydrographic Bureau (IHB) in Monaco and to the Central Bureau suggested above. For future work the use of narrow-beam echosounders is recommended.

(d) Sediment discharge

Other important needs

(a) Sediment coring

Our knowledge of sediment distribution and history is still scanty. Additional data are badly needed:

(i) To obtain information on ridges.

(ii) To identify materials and age of A" and B" horizons.

In each well drilled all possible information is to be obtained such as heat-flow measurements, velocity survey, oriented sampling for remanent magnetism, radiometric age, etc. This holds both for wells on land and JOIDES holes.

(b) Recommendations for deep sea drilling project JOIDES

Recommendations for locations of holes to be drilled are to be made to NSF.

(c) Dredging

Obtaining of rock samples from submarine scarps is to be greatly intensified.

(d) Aeromagnetic survey

Existing ship magnetic data for the Caribbean are unsuitable for preparing some magnetic maps of primary importance. Serious consideration should be given to an aeromagnetic survey of the entire area.

(e) Heat-flow

A pattern of high heat-flow has been established behind Pacific Island arcs. Survey ships should include wherewithal to gather this information at sea. Heat-flow measurements to be taken in all wells drilled and suitable.

(f) Shelf surfaces and slopes

Surveying of erosional and depositional surfaces on shelf areas requires dredging and high frequency, low energy sparker or similar device, a usually neglected instrumentation.

Areas of special interest for dominantly marine research

(The figures in brackets give the suggested order of priority taking into account the present programmes)

(a) Yucatan Basin (2)

Is this basin different from the others and why? No A" and B" reflectors?

(b) Cayman Ridge (1)

Comparison with Nicaragua Rise.

(c) Campeche Bank (3)

Strong and rather strange magnetic anomalies

(d) Nicaragua Rise (2)

Apparently continental but still little known; southern margin complicated.

(e) Providencia Area (2)

Nature and reason for volcanism insufficiently known.

(f) Curaçao Ridge (3)

Geophysics suggest great sedimentary thickness; transition to areas further south.

(g) Beata Ridge (1)

Possibly sunken geology; nature crucial to test theory of rotation.

(h) Aves Swell (1)

Dredging, drilling, geophysical surveying to disclose whether this is an old windward arc position or something quite different.

(i) Windward Arc (1)

Boundary between Lesser Antilles and Atlantic Ocean is crucial for testing present theories.

(j) Ridge of islands north of Venezuelan coast (3)

The islands have partly Antillean partly Venezuelan geology; the ridge is obliquely cut by morphologic and geophysical features.

(k) West end of Puerto Rico Trench (2)

The termination of this feature is very puzzling.

Suggestions for JOIDES holes

(a) Aves Swell;

(b) Beata Ridge east side to drill below A" and B";

(c) Sea floor north of Puerto Rico Trench;

(d) Cayman Ridge;

(e) Yucatan Basin.

4.3 Report of Section III - Marine Biology

In general the rule was established not to allow papers to be presented whose authors were not attending the Symposium, since a constructive discussion could not be carried on in the authors' absence. Nevertheless, the Chairman of the Symposium authorized Dr. R. Margalef paper "Pelagic Ecosystem in the Caribbean Sea" to be read by Dr. Cervigón, of Venezuela, who collaborates with Dr. Margalef in his work on the ecology of the Caribbean Sea.

In studying the distribution of the topics dealt with in this section one notices a preponderance of papers dealing with systematics. Out of a total of 33 manuscripts submitted in this section (of which 23 were read) 12 were studies of systematics, while the remaining 11 dealt with various topics distributed as follows:

Nutrients and primary production	3
Ecology	2
Physiology	2
Programmes	3
Bibliography	1
Systematics	12
Total papers read	23

After each reading a suitable period of time was devoted to discussion of the paper. In practice these periods were added to in order to carry on the discussions through the groups forming the subsections.

A Marine Biology Working Group met on 25 November 1968 and drafted the final text of the recommendations of Section III to the International Coordinating Group for CICAR.

Identification of Problems and Recommendations for CICAR

Plankton

(a) Identification of basic problems

(i) Available information about the taxonomy, distribution, abundance, seasonal speciation, sequence and succession of planktonic communities * is incomplete; this information is essential in order to identify problem areas; such as areas of low and high productivity, areas of upwelling and areas of sinking.

(ii) Available knowledge of the life cycle of plankters and how environment affects their organization is notably lacking.

(iii) Sufficient data do not exist for establishing the turnover rate of phytoplankton and its relationship to secondary production, factors that affect our total understanding of the food chain.

(iv) There is no standard method for quantitative measurement of secondary production.

(v) Very little is known of the mid-water macroplankton and of its food chain in the water column from the thermocline to the bottom, on the shelf, on the slope and on the ocean bottom.

(vi) Available knowledge of the influence of environmental factors on the regulation of primary productivity blooms is incomplete; the same is true of nitrification and denitrification processes and apparent carbon absorption in aphotic levels.

(b) Recommendations

(i) Intensify research programmes aimed at improving knowledge of the taxonomy, distribution, abundance, seasonal speciation and the sequences and successions of planktonic communities so as to achieve a better understanding of the dynamics of production at the various trophic levels.

* Refers to phytoplankton and zooplankton

(ii) Encourage specialized studies of the geographical distribution, life cycles and environmental factors that affect zooplankters.

(iii) Carry out long-term measurements of the turnover rate of phytoplankton and its relationship to secondary production, including the influence of environmental factors that affect each food chain.

(iv) Systematic plankton sampling should be carried out (using, for example, the Hardy plankton recorder) while, at the same time, a Sorting Centre to analyse samples should be established.

(v) Start a cooperative programme to study mid-water organisms from the thermocline to the bottom, on the shelf, on the slope and on the ocean bottom, using adequate conventional equipment.

(vi) Study the evolution in time and space of the distribution of mineral nutrients and other direct or indirect factors that affect primary production so as to acquire a better understanding of its dynamics and mechanisms; as well as of chemical synthesis by bacterial populations.

Benthos

(a) Identification of basic problems

(i) There is insufficient information available about the taxonomy, ecology, biogeography and physiology of benthic communities *.

(ii) Data on standing crop of algae and marine phanerogams are scarce.

(iii) Since absorption indexes of benthic algae and marine phanerogams are virtually unknown, it is difficult to determine production of organic matter.

(iv) Zonation, on the basis of depth, of benthic communities and the factors that control their distribution constitute an important problem about which very little information is available.

(b) Recommendations

(i) More thorough study of the taxonomy, ecology, biogeography and physiology of benthic communities through a programme of cooperative investigations.

(ii) Intensify research, using both direct and indirect methods, to estimate the standing crop of algae and marine phanerogams.

(iii) Carry out systematic measurements of the primary production of algae and marine phanerogams. Results should be expressed in gr. $C/m^2/g$ dry weight/year.

(iv) Start and develop mariculture projects both in laboratories and in situ.

(v) Sponsor the establishment of cooperative programmes with institutions both within and outside the region to investigate tropical and subtropical marine flora and fauna.

General consideration in respect to the area

The situation that will arise with the probable construction of an Inter-oceanic Sea Level Canal between the Atlantic and the Pacific Oceans urgently requires a large-scale cooperative programme to unite the efforts of all institutions both within and outside the area to prepare an inventory of the marine biotope of America.

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* Flora and fauna

4.4 Report of Section IV - Fishery Resources

To facilitate an appraisal of the present status of the fishery resources of this region and an examination of the current research activities, the papers presented were considered in the following groups:

1. Tunas and their exploitation
2. Clupeoids
3. Demersal fishes
4. Crustacea
5. Miscellaneous resources (molluscs, cephalopods, sharks, turtles)
6. Fishery prospection in general

Tunas and their exploitation

Several tunas and related species occur in the Caribbean region; they are: Yellowfin (Thunnus albacores), Bigeye (Thunnus obesus), Skipjack (Katsuwonus pelamis), Blackfin (Thunnus atlanticus), Bluefin (Thunnus thynnus), Albacore (Auxis spp.) Blue Marlin (Makaira nigricans); other species of the genera Xiphias, Acanthocybium, Sarda, Istiophorus, Makaira, and Tetrapturus occur in the area. The total annual landings are estimated at about 30,000 metric tons in 1965. Yellowfin tuna constitutes over one third of the landings. The catch is taken in two separate fisheries; in one, the high-sea longline fishery, the catch consists chiefly of yellowfin, bluefin, bigeye and albacore; the other, a near-shore surface fishery (principally in Cuba and the Lesser Antilles) is based on "bonitos" (mostly skipjack and blackfin). Prospects for enlargement of the longline fishery are not promising. A surface fishery might be realizable, perhaps by purse-seine fishing; recent experimental fishing by Puerto Rico should shed considerable light on this problem.

The papers presented dealt with: the fisheries for these species, the state of the stocks of yellowfin tuna, the distribution of post-larval swordfish, and the feeding habits of skipjack. Any research programmes on these species in this region can draw on an existing body of information in the literature. Moreover, the state of tuna stocks of the Atlantic region generally was recently reviewed by the FAO Group of Experts on Tuna Stock Assessment. From all this material, it is clear that the major problems, at this time, concern stock identity and distribution patterns. With respect to the former, the task is to determine more accurately the relations (such as exist) of these stocks with those of other parts of the Atlantic, and to examine the growth, mortality and recruitment characteristics of the stocks. The latter is a matter of establishing a more precise account of the distribution patterns and of the relations of these patterns with the dynamic features of the habitat they occupy. Among the items of the CICAR could be included a Caribbean tuna tagging programme. Both these sets of tasks are especially suitable for attack by international collaboration and indeed can be dealt with satisfactorily only by such collaboration; in particular the work will be brought to a successful conclusion only if synoptic accounts of the marine climate become available. The importance of some of these matters was emphasized during the discussions when reference was made to cyclic variations, observed in the Venezuelan fishery in the apparent abundance of the yellowfin: these variations presumably reflect periodic shifts of concentration of the yellowfin in response to changes in the marine climate. Another matter discussed was the feeding habits of yellowfin and bigeye; these fish were reported to take bait only at certain times of the day; it was suggested that studies of the feeding behaviour and preferences of these species now in progress might lead to improvement of the near-shore surface fishery.

New observations on the distribution of the larvae of swordfish were reported; these observations indicated the presence of a spawning area in the Yucatan Channel and another at the northern edge of the equatorial current and it was suggested that opportunity should be taken through CICAR to prosecute a systematic programme of fish egg and larvae sampling, however, this survey should be not only for Xiphias, but also for other species of commercial importance.

Clupeoids

There is a varied clupeoid fauna in the region, comprising species of the genera Opisthonema, Sardinella, Harengula, Cetengraulis, Anchoa and others. The taxonomy of this group still presents serious problems evidenced by the statement of one of the authors that in the reported catch of sardines in Venezuela, mainly constituted by Sardinella anchovia, includes a small proportion of a second type whose degree of taxonomic differentiation is uncertain.

The total Venezuelan catch is about 40,000 metric tons per year. The indications of the presence of important clupeoid resources off the coast of Surinam, and observations of members of this group in other places throughout the region suggest that some important increase of catch can be expected. A report of observations of the occurrence of some of these species, by means of night-light attraction

and pumping, in the eastern Caribbean Sea suggest that the real abundance of these species has not hitherto been correctly assessed because the observational techniques were inappropriate to the behaviour of these species; previous attempts to assess the commercial value of the island and reef areas of the Gulf of Mexico and Caribbean Sea have resulted in fact in discouraging estimates. New exploratory techniques will be required to obtain reliable quantitative estimates of population densities and availability. These techniques must make full use of recent advances in echo sounding equipment and practice, of other improvements in fish-searching equipment, and of remote sensing apparatus. It is recommended that the CICAR programme should include a project for utilization of such equipment with standard calibrated instruments and experienced operators. These matters were discussed in considerable detail under sub-section "Miscellaneous resources".

Demersal fishes

The tropical Atlantic fish fauna is rich and diverse, and falls, as recently expanded research has shown into distinct patterns of distribution. These patterns consist of: a north continental fauna, a south continental, and an insular. The north continental fauna extends from Cape Canaveral on Florida, around the Gulf of Mexico to Yucatan and through Cuba in diminishing representation to Hispaniola and Jamaica. The southern species occur along Brazil's north coast, the Guianas and Venezuela and in pockets in the mud shadows in the river mouths from Colombia to Nicaragua. The continental pattern is typified by the Sciaenidae. The collections, on which these conclusions are based, indicate that the ecotic characteristics of the area, and not some physiographic barriers, have separated the continental fauna from the insular fauna. The latter is extremely diverse and the fishery exploiting it is adapted to the capture of a wide variety of species. Many of these species feed on the broad sandy and grassy flats adjacent to reefs, and find shelter in the reef itself; islands with limited shallow-water area near the reef have a small fish populations: anything that reduces these areas or changes the reef structure will reduce the fauna (hence the use of explosives on reefs should be prohibited) whilst artificial reefs and similar means of developing the habitat will increase the fauna.

Reef communities are extremely complex in structure and dynamics and these must be understood before it will be possible to evolve suitable regimes (gear and methods) for their exploitation, and even more for any moves to improve them. The studies of the stocks will include underwater observation of behaviour and quantitative appraisal of the populations; they must be supplemented by ecological studies of the communities themselves.

An important group of papers at this Symposium dealt with exploratory fishing and appraisal of the bottom resources of this region. These papers reflect the very great amount of such work that has been carried out in this region by many fishing methods over an extended period of years. Such work has shown a large snapper, grouper and grunt potential. The U.S. Bureau of Commercial Fisheries estimates the resource potential as of the order of 40,000 metric tons for the Caribbean, but it is not clear whether this estimate relates only to a few groups or to the entire fauna, nor whether it is intended to be an estimate for the entire region as defined for this Symposium. There are, however, indications from the papers that other resources exist. Local fisheries, operating chiefly with hook and line and with traps, obviously have limited prospects; but trawl fishing by both local and foreign vessels is expanding, and the fishermen seek to project their operations on to the continental slope: clearly appraisal of the stocks under exploitation, and a realistic account of the distribution of other stocks and assessment of their magnitude, on global basis, is urgently necessary. Such a work should make the fullest use of all accumulated data, the analysis of these data should provide a basis for the planning of further work to make use of standardised sampling and reporting procedures to facilitate pooling and computer processing of data for common use. For this purpose recourse should be had to the FAO fishery data centre and to any other computer facilities (especially those of the U.S. Bureau of Commercial Fisheries) which might be accessible.

At the same time, it was pointed out that a major feature of Caribbean bottom topography is the ruggedness of the shelf and the abundance of reefs and banks so that for better efficiency of trawling operations more detailed bottom charts are needed; the CICAR programme might seek to develop these charts.

Crustaceans

The Caribbean Sea and adjacent areas are very rich in crustacean resources, more especially in those of the penaeid shrimp and lobsters. The grounds of the Gulf of Mexico, the Gulf of Venezuela and the continental shelf of Surinam, carry stocks supporting some of the most important shrimp fisheries of the world. Although production has continued to increase in recent years, there have been significant fluctuations and in some cases indications of what may be overfishing. Considering the high international price for shrimp, the protection of these resources and maintenance of the fisheries is ob-

viously of considerable importance to the countries of this region. That this importance is recognized by governments was underlined by the FAO World Conference on Shrimps and Prawns, Mexico, 1967, and is shown by the many research programmes currently in operation. The efficiency of these programmes could be heightened by appropriate arrangements such as were proposed by the World Conference, to promote and assist exchange between the several institutions engaged in the work. At the same time these programmes could be further aided by cooperative work, which CICAR could promote on 1) an environmental frame, 2) bottom charts of the continental shelf and slope, 3) the identification of larvae and the study of the patterns of distribution of the larval stages.

Although the presented papers suggested that, in the main, these fisheries appear to be in healthy condition, the clear indications of significant decline in particular cases point to the urgent need to develop the account of the dynamics of the stocks, to a level at which it will be possible to formulate effective management measures. One of the papers presented emphasized that measures of shrimp mortality, on which sound management programmes would be dependent, have yet to be made; it points out that the estimates appearing in literature are inaccurate and of such a wide range that management measures based on them have been in conflict. Opinions were expressed that the influence exerted on shrimp populations by environmental changes was more significant than that exercised by fishing and reference is made in a report on the Venezuelan shrimp fishery to the effects that might have been produced by the cutting of a channel through the sill that separates Lake Maracaibo from the Gulf of Venezuela.

An account was given of recent developments; in the area, in the cultivation of shrimp; the techniques seem to be very promising.

Despite a wide distribution of spiny lobster, probably throughout the region, the exploitation is not well developed except in a few particular cases. Catches are largest in Cuba, northeast Brazil, British Honduras, Nicaragua, Puerto Rico, Jamaica and Mexico, but the statistics are variable in accuracy and completeness and no valid estimate of total catch for the region is available. It may be possible to expand a few lobster fisheries, especially at the southern edge of the Caribbean Sea, but most lobster stocks appear to be fully exploited.

There was a vigorous discussion of the use of traps in this fishery and of the management measures needed, more especially those related to protection of recruitment.

Miscellaneous resources (molluscs, cephalopods, sharks, turtles)

Reviews were presented of the present status of fisheries exploiting resources which at present are of relatively minor importance although, nevertheless, contributing to the general economy and in particular cases being of much importance to local economies; some of these, as for example the mangrove oyster (Crassostrea mangle) and the mussel (Perna perna), are potentially of very great importance. The application of cultivation methods, the rationalisation of the operations, and the adoption of protective measures against pollution and against destruction of mangrove stands, could lead to substantial development of these industries. As in the case of other groups, development of these industries could be promoted by the establishment of international machinery through which there could be rapid exchange of information on local experience.

A review of cephalopod fisheries, referring to those of other parts of the world as well as those of the Caribbean, was of special interest; it drew attention to the little recognised fact that in some parts of the world the catch from these fisheries is very great, and showed that the Caribbean fisheries for this group, although small, are much more widely distributed than is commonly known. It reported that although the region is rich in species of cephalopod only 6 species of squid and 4 of octopus are considered to be of commercial value. The reviewer expressed the opinion that the resources have a vast potential but pointed out that no assessment of them was yet possible. Since the fisheries would yield products of value for international trade, the fishery should be developed, but for this purpose there should be a general survey. Since much of such fisheries would take place on the high seas, the assessment of the resources would be a matter of international concern and CICAR could offer opportunity for such work.

The sea turtles of the Caribbean are among the classical resources of the area; the rate of their exploitation has increased in recent years and Chelonia (perhaps other genera as well) seems on the verge of disappearing as economic asset, if not as species. The saving of these turtles will require an international effort of which the elements would include 1) a nesting survey, 2) a seasonal tagging programme, 3) effective protection through appropriate legislation effectively enforced, 4) promotion of turtle husbandry.

General prospecting

Considerable exploratory and prospecting work is in progress, under national projects and under UNDP and bilateral development programmes; several references have been made in earlier sections to this work. The magnitude of these efforts and the costs of the operations make it imperative that arrangements be set up, as speedily as possible, for mutual assistence between these projects. Each project should be able to draw upon the total results of such fisheries survey work, for its own planning and for control of the conduct of its operations, and should feed its information into the common pool; the arrangements should be such as to make this possible in a convenient way; at the same time these arrangements should be such as to afford coordinating services whenever those responsible for two or more projects should see that coordination could lead to economy of effort and to increased efficiency. The scope of such activities will expand considerably in this area in the coming years, through CICAR itself and the many visiting vessels that will be part of its programme, and through the developmental projects, and therefore it is recommended to FAO that it expand its fishery data centre, as part of the World Ocean System of data exchange and in collaboration with national institutions, so as to be ready and equipped to meet this need as it grows. In this connection it is also important, as frequently recognised during the discussions, that FAO should assist member countries of the area in their efforts to develop and improve their systems for collection of catch and effort statistics. Furthermore, an extremely interesting paper was presented giving an account of aerial remote sensing reconnaissance of surface schooling fish, and it was obvious that development of such systems, which could be encouraged by CICAR, could play a critical part in the fisheries research of the region and in the fishing operations themselves.

General

The resource biologists see the CICAR programme as one which should lead to more complete, efficient, and rational exploitation of living resources of the area. The programme could contribute to this by creating a better understanding of the influence of the environment on the abundance and distribution patterns of fishery resources. The biologists could hope that biological and physical oceanographers would design their activities with the overall objective in view. Resource biologists believe that they can justifibly solicit the establishment of an environmental frame, through which they would be provided a continuing service of synoptic reporting on the marine climate, corresponding to that service which on land is provided for agriculture, forestry and other resource scientists by meteorological bureaux. Moreover, the fishery programmes of the region could contribute significally to the development and maintenance of such a system. The development of this element of CICAR should take into account the plans for the Integrated Global Ocean Station System (I.G.O.S.S.).

The specific elements of the research programme cannot be enunciated at this time: resource papers presented at this Symposium which report much of the progress already made, at the same time reveal many gaps in knowledge and deficiencies of methodology. For example, it is clear that much more complete and accurate production and effort statistics are required; that life history, plankton, population dynamics and other classical biological studies are required; that the existing FAO fishery data centre should be used; that more detailed bottom charts are required and that in special situations studies should be made of upwelling phenomena. A closer examination of the full text of each paper and of the discussions, together with a review of current projects plans, would permit the development of an effective programme.

It is conceived that the CICAR programme will have two principal opportunities. The first of these is to identify the principal research problems whose solution is required for the more complete and rational exploitation of living resources. The second is to encourage cooperative research with respect to these problems and to avoid wasteful duplication of effort.

The biologists believe that CICAR might seize these opportunities through two principal courses of action. One of these would be directed toward assisting the countries of the region develop their research institutions for a full participation in the identification of problems and in the planning and conduct of research; for these purposes, it is suggested that special attention be given to the possibilities of associating training projects with CICAR and of employing the CICAR activities as occasions for field and laboratory training of the staffs of these countries. The other course of action aimed at elaborating a pattern of research activities to achieve the designated objectives, would consist of assisting and integrating the many national elements, of providing such coordination of these activities as might serve to increase their effectiveness, of promoting such standardisation and intercalibration as might usefully facilitate exchanges, and of organizing such cooperative work (especially that to be participated in by countries from outside the region) as may be desirable to complete the overall pattern of research.

Recommendations

Although the biologists believe, as they have indicated in "Miscellaneous resources", that the detailed programme relating to resources within CICAR should be formulated by the International Co-ordinating Group, after a deeper study of reports and programmes than has been possible during this meeting, the survey they have made and presented in the preceding sections permits them to present the following list of representative problems.

I. Particular research recommendations

Tuna and tuna fisheries

1. Stock identity: the relations of the Gulf and Caribbean stocks of tunas and similar species with those of other parts of the Atlantic should be determined; the growth, mortality and recruitment characteristics of these stocks should be measured.

2. Distribution patterns: a more precise account of distribution patterns and of the relations of these patterns with dynamic features of the habitat should be prepared and for this and other purposes the CICAR programme might include a Gulf and Caribbean tuna tagging programme.

3. Feeding behaviour: a study should be made of this behaviour with a view to improvement of fishing methods.

4. Eggs and larvae: (see II. 1.)

Clupeoids

5. The Gulf and Caribbean clupeoids fisheries offer good prospects for development, and extensive use for this purpose should be made of modern acoustic methods for speedier estimation of fish abundance (see II. 2.).

Demersal fishes

6. Reef communities: both fish population and ecological studies should be made of these communities.

7. Stock magnitude and density: all data concerning these stocks should be compiled and anlysed; FAO's Fishery Data Centre and other similar facilities should be developed for this purpose.

8. Fishing ground characteristics (see II. 3.).

Crustacea

9. Data exchange: implement of the recommendation of the FAO World Scientific Conference on the biology and cultivation of Shrimp and Prawns for exchange of data, information and experience within the region, and these arrangements should be expanded also to cover lobsters (see III. 2.).

10. Cooperation: in order to strengthen the programmes of research on crustacea in the Gulf and Caribbean, CICAR should:

    a. provide an environmental frame (see II. 5.)

    b. provide bottom charts (see II. 3.)

    c. conduct a programme for identification of shrimp larvae and study of their distribution.

11. Population dynamics: the management of shrimp fisheries generally throughout the world is held back by the inadequacy of the models which currently are used to represent the structure and dynamics of the populations; the mortality rates are notoriously unreliable. Both the theoretical formulation of the models and the gathering of data to be fed into them need careful and urgent attention. The current work in this field in the Gulf and Caribbean needs to be reviewed and a joint attack on the problems should be made by the experts concerned.

Miscellaneous resources

12. Mariculture of oysters and mussels: these industries could be developed by application of techniques already employed in other regions and by the adoption of protective measures; international exchange to promote such development should be stimulated.

13. Cephalopod resources: every opportunity should be taken during CICAR operations to observe and to record occurrence on abundance of these resources. Ways should be sought to improve the methods and techniques for those assessments.

14. Turtles: an active programme of research including tagging experiments in adequate scale, to provide the scientific basis for the management of these stocks should be developed.

General prospecting

15. Planning and conduct of surveys: arrangements should be developed for mutual assistance between survey projects, to facilitate their planning and conduct.

16. Data exchange: FAO should develop its Fishery Data Centre to provide a service to these projects.

17. Remote sensing reconnaissance: CICAR could encourage the development and utilization of systems for such reconnaissance.

II. Major proposals for CICAR

The foregoing examples have focussed attention upon several principal matters, each common to a number of resources and countries with respect to which a major effort should be made in CICAR.

1. Eggs and larvae surveys: for the purpose of accelerating the study of the distribution and abundance of important commercial species, a specially designed egg and larvae survey should be included in the overall plankton programme of CICAR. Prosecution of this survey requires:

   a. statistical design of the sampling programme;

   b. standardization of methods and utilization of agreed equipment;

   c. intensive work on the taxonomy of these aienomorphs;

   d. particular facilities for sorting and counting this material;

   e. arrangements for speedy processing of the data.

   This survey also must be closely related with the environmental frame.

2. Echo surveys of juvenile and adult stocks: advantage should be taken of the presence in the area and (particularly in the lesser known parts of the area) of vessels of countries participating in the cooperative study and of those operated under the UNDP/FAO and bilateral aid schemes, to carry out echo surveys of stocks.

3. Bottom charts and position aids: every effort should be made in the course of geological and oceanographic work to contribute to the improvement of bottom charts, so urgently needed for fishery purposes, especially of those relating to the continental slope on to which the fisheries are expanding; in selected areas it will be necessary to seek intensive and concerted effort. All the survey and research work will be greatly improved in its efficiency if the positioning aids can be improved.

4. Statistics: the success of work on fishable stocks, in the course of CICAR, will greatly depend upon the efficiency and accuracy of the systems for collection of catch and effort statistics; governments should make a special effort to develop their systems and FAO should give its aid to this work. A regional statistical system with its own regular bulletin, is needed.

5. Environmental Frame: high priority should be sought for the establishment of an environmental frame within which the field work, not only of fisheries, will be prosecuted. There will, of course, be methodological problems in deciding upon the density and type of observational stations to be provided, for particular purposes, in each subdivision of the area.

III. Guest proposals

1. In view of the existing large programmes on fishery resources at present being executed in the areas and of the complexity of the resource research to be undertaken under CICAR, it is considered:

   a. that national delegations to the International Coordinating Group should include an expert in living resource sciences;

   b. that and Assistant International Coordinator for Fisheries be appointed;

   c. that it should be the duty of the International Coordinating Group to elaborate detailed resources programmes for CICAR.

2. In order to facilitate exchange of information, review of results and the coordination of effort among the scientists of all countries interested in the Caribbean and adjacent area FAO and UNESCO should examine the desirability of setting up appropriate machinery either under the form of additional symposia or other meetings on selected subjects on an ad hoc basis or of some more formal structure. To reduce the travel problems associated with international meetings the following that may be organized should be associated with the meetings of existing organizations, to the extent that this might be practicable.

3. In view of the evidence presented of a crisis prevailing in turtle populations of the region, international attention, e.g. FAO, World Wildlife Fund, IUCN, etc., must be focussed on measures that must be adopted for prevention of destruction of stocks of these species.

ANNEX 1

LIST OF PARTICIPANTS

E. ALLERSMA
Waterloopkundig Laboratorium
Noordoostpolder, DE VOORST
Netherlands

M. ALVAREZ
Comité Nacional de Oceanografía
Montevideo
Uruguay

R. ALVAREZ
Universidad Central de Venezuela
Facultad de Ingeniería
Caracas, Venezuela

A. ALVARINO DE LEIRA
Scripps Institution Oceanography
La Jolla
California, U.S.A.

N.R. ANDERSEN
9731 Wyman Way
Upper Marlboro
Maryland 20870, U.S.A.

L.N. ANDREEVA
Institute of Oceanology
Academy of Sciences of the USSR
Moscow, U.S.S.R.

A. ANTONIUS
Instituto Oceanográfico
Apartado Postal 94
Cumaná, Venezuela

F.J. ARAGNO
Casilla de Correo 42, SAN MIGUEL
(F.C.N.G.S.M.)
Pcia.de Buenos Aires, Argentina

D.D. ARDEN (Jr.)
Signal Exploration (Jamaica) Co.
21 Oxford Road
Kingston 5, Jamaica

W.D. ATHEARN
Department of Marine Sciences
University of Puerto Rico
Mayaguez, Puerto Rico 00708

A. AYALA-CASTANARES
Instituto de Biología
Ciudad Universitaria
Apartado Postal 70-223
Mexico 20, Mexico

N. BAHAMONDE
Antonio Acevedo Hernandez 128
Santiago, Chile

A. BALLESTER
Instituto de Investigaciones Pesqueras
Paseo Nacional s/n
Barcelona, Spain

BARNARD
Geology Department
University College London
Gower Street
London, N.W.C. 1, U.K.

H.L. BARRALES
Liaison Officer for Marine Sciences in L.A.
Regional Centre for the Advancement of Science for L.A.
Bulevar Artigas 1320-24
P.O. Box 859
Montevideo, Uruguay

F.M. BAYER
Institute of Marine Science
University of Miami
1 Rickenbacker Causeway
Miami, Florida 33149, U.S.A.

W.H. BAYLIFF
Departamento de Pesca
Apartado Postal 3318, Zona 4
Panamá, Panamá

I.M. BELOUSSOV
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
1 Sadovaya Street
Lublino
Moscow Zh. 387, U.S.S.R.

A. BELLIZZIA G.
Dirección de Geología
Ministerio de Minas e Hidrocarburos
Torre Norte Piso 19
Caracas, Venezuela

A. BEN-TUVIA
Marine Biology Section, FAO
Via delle Terme di Caracalla
00100 Rome, Italy

H.L. BERRYHILL
231 Rosebud St.
Corpus Christi
Texas 78404, U.S.A.

E. BIESTER
Institut für Hochseefischerei
Rostock-Marienehe
Democratic Republic of Germany

T.K.S. BJORNBERG
Departamento de Zoología
Universidade de Sao Paulo
Caixa Postal 8105
Sao Paulo, Brazil

E.L. BÖHM
University of the West Indies
Biochemistry Department
Mona, Kingston
Jamaica

I. BONNELLY DE CALVENTI
Instituto de Biología Marina
Universidad Autonoma de Santo Domingo
Santiago 22
Santo Domingo, República Dominicana

A.H. BOUMA
Department of Oceanography
TEXAS A & M UNIVERSITY
College Station
Texas 77843, U.S.A.

O.D. BORODULINA
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

J.M. BOWEN
Compañía Shell de Venezuela
Apartado 809
Caracas, Venezuela

H. BRATTSTRÖM
Biological Station
Espegrend
N-5065 Blomsterdalen, Norway

R.P. BRIGGS
c/o U.S. Geological Survey
GPO Drawer 2230
San Juan 00936, Puerto Rico

A. BRUINENBERG
Director, Department of Meteorology
Willimstad
Curaçao, Netherlands Antilles

H.R. BULLIS (Jr.)
Bureau of Commercial Fisheries
Exploration Fishing and Gear
Research Base
Pascagoula
Mississippi 39567, U.S.A.

V.A. BURKOV
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

M.J.A. BUTLER
Bellairs Research Institute
of McGill University
St. James
Barbados, W.I.

E. CADIMA
FAO
Via delle Terme di Caracalla
00100 Rome, Italy

E.W. CAKE (Jr.)
Department of Oceanography
Florida State University
Tallahassee
Florida, U.S.A.

Th.A. CAREFOOT
Acting Director
Bellairs Research Institute of McGill University
St. James
Barbados, W.I.

A. CARR
Department of Zoology
University of Florida
Gainesville
Florida, U.S.A.

J. CARRANZA
Technical Advisor
D.G.E.T.I.C.
Secretary of Public Education
Guatemala 10 - 201
Mexico 1, D.F., Mexico

H. CASALE
Dirección de Hidrografía y Navegación
Observatorio Cagigal
Apartado Postal No. 6745
Caracas, Venezuela

L.B. CAVALCANTI
Laboratorio de Ciencias do Mar
Caixa Postal 1076
Recife - Pernambuco
Brazil

R.G. CECIL
Department of Geography
McGill University
Montreal 2, Canada

F. CERVIGON
Estación de Investigaciones Marinas de Margarita
Punta de Piedras
Apartado 144
Estado Nueva Esparta, Venezuela

J.L. CIFUENTES LEMUS
Av. Guauhtémoe No. 80, 6° Piso
Mexico City, Mexico

F. CREUTZBERG
Director, Caribbean Marine Biological Institute
Piscaderabaai
P.O. Box 2090
Curaçao, Netherland Antilles

R.A. CURRA
Instituto Oceanográfico
Universidad de Oriente
Apartado Postal 94
Cumaná, Venezuela

L.Ph. DA COSTA FERNANDEZ
Directoria de Hidrografía e Navegacao
Ministerio de Marinha
Rio de Janeiro, Guanabara
Brazil

A.E. DAMMANN
Cruz Bay
St. John
Virgin Islands

R. DAVILA CUEVAS
Facultad de Ciencias
Universidad Nacional Mayor de San Marcos
Ciudad Universitaria
Apartado 2973
Lima, Perú

M. DIAZ PIFERRER
Universidad de Puerto Rico en Mayaguez
Colegio de Agricultura y Artes Mecánicas
Mayaguez, Puerto Rico 00708

J.L. DIBBS
Caribbean Fisheries Development Project
"The Reef"
Fontabelle, P.O. Box 640 C.
Barbados, W.I.

S. DOBKIN
Department of Biological Sciences
Florida Atlantic University
Boca Raton
Florida 33432, U.S.A.

Th. W. DONNELLY
Department of Geology
State University of New York
Binghamton
N.Y. 13901, U.S.A.

R. DORRESTEIN
K.N.M.I.
De Bilt, The Netherlands

F. DURANT
Fisheries Research and Development Project, FAO
Apartado 889
Maracaibo, Venezuela

D. EISMA
Nederlands Instituut voor Onderzoek der Zee
Buitenhaven 27
Den Helder, The Netherlands

R.W. ELLIS
Mision FAO en Costa Rica
Apartado 2933
San José, Costa Rica

I. EMILSSON
Mail Division, Havana Pouch
UNESCO
Place de Fontenoy
Paris 7, France

J.J. EWALD
Fisheries Research and Development Project, FAO
Apartado 889
Maracaibo, Venezuela

G. FEO-CODECIDO
Compania Shell de Venezuela
Apartado 809
Caracas, Venezuela

E.J. FERGUSON WOOD
Institute of Marine Sciences
University of Miami
1 Rickenbacker Causeway
Miami, Florida 33149
U.S.A.

O.O. FERNANDES
Ministry of Petroleum and Mines
P.O. Box 96
Port of Spain
Trinidad and Tobago

S.C. FRY
National Council on Marine Resources and
Engineering Development
Executive Office of the President
Washington, D.C. 20500
U.S.A.

J. FUKUOKA
Instituto Oceanográfico
Universidad de Oriente
Apartado Postal 94
Cumaná, Venezuela

E.K. GANESAN
Instituto Oceanográfico
Universidad de Oriente
Apartado Postal 94
Cumaná, Venezuela

L. GARCIA PINTO
Universidad del Zulia
Centro de Investigaciones Biológicas
Maracaibo, Venezuela

L.E. GARRISON
U.S. Geological Survey
P.O.B. 1916
Copus Christi
Texas, U.S.A.

R.C. GENTRY
National Hurricane Research Laboratory
P.O.B. 8265
University of Miami Branch
Coral Gables
Florida 33124, U.S.A.

R.A. GEYER
300 Greenway Dr. Bryan
Texas 77801, U.S.A.

G. GIERMANN
Assistant Secretary
Intergovernmental Oceanographic Commission
Place de Fontenoy
Paris VII, France

G.S. GIESE
Department of Marine Sciences
University of Puerto Rico
Mayaguez, Puerto Rico 00708

F.S. GNERI
Apartado Aereo 17798
Bogotá 1, Colombia

D.R. GONZALEZ
Avenida Santa Rosa No. 78
Cumaná, Estado Sucre
Venezuela

L.A. GONZALEZ
Dirección de Geología
Ministerio de Minas e Hidrocarburos
Torre Norte Piso 19
Caracas, Venezuela

J.M. GONZALES CARDULIZ
Instituto Nacional de la Pesca
Centro de Investigaciones Pesqueras
Playa Habana
Bauta, Cuba

I.M. GOODBODY
Zoology Department of the University of
the West Indies
Kingston 7, Jamaica

M.M.R. GOODWIN
c/o J. Brown Corea's Store
44 Princess Gate
London, S.W. 1, U.K.

J.R. GOULET (Jr.)
Bureau of Commercial Fisheries
Tropical Atlantic Biology Laboratory
75 Virginia Beach Drive
Miami, Florida 33149
U.S.A.

R.C. GRIFFITH
FAO/UNDP Fisheries Research and Development
Project
Apartado 2578
Caracas, Venezuela

G.B. GROSS
American Embassy
Mexico, D.F., Mexico

D.J. GUITART MANDAY
Instituto de Oceanología
Academia de Ciencias de Cuba
La Habana, Cuba

G. GUNTER
Gulf Coast Research Laboratory
P.O. Box AG
Ocean Springs
Mississippi 39564, U.S.A.

L. HAMMER
Institut für Meereskunde
Abt. Meeresbotanik
Kiel 23
Hohenbergstrasse 2
Federal Republic of Germany

B. HEEZEN
Palisades
New York, U.S.A.

J.R. HEREDIA
Oficina Nacional de Pesca
Ministerio de Agricultura y Cría
Caracas, Venezuela

H.H. HESS
Princeton University
Department of Geological and Geophysical Sciences
Guyot Hall
Princeton, New Jersey 08540
U.S.A.

H. HILDEBRAND
University of Corpus Christi
Corpus Christi
Texas 78411, U.S.A.

L. HOWELL-RIVERO
Apartado Postal 8164
UNESCO
Panamá, Panamá

B. HSU
Caribbean Fisheries Development Project, FAO
"The Reef"
Fontabelle, P.O. Box 640 C
Barbados, W.I.

C.L. HUBBS
Prof. of Biology Emeritus
University of California
Scripps Institute of Oceanography
P.O.B. 109
La Jolla, California 92037
U.S.A.

R.J. HURLEY
Institute of Marine Sciences
10 Rickenbacker Causeway
Virginia Key
Miami, Florida
U.S.A.

C.P. IDYLL
Institute of Marine Sciences
University of Miami
Miami, Florida 33149
U.S.A.

S. INCHAUTEGUI
Instituto de Biologia Marina
Universidad Autonoma de Santo Domingo
Santiago 22, Santo Domingo
Rep. Dominicana

R. INGLE
Marine Laboratory
Maritime Base, Drawer F
St. Petersburg
Florida, U.S.A.

F. JELDES
Instituto de Biologia Marina
Universidad Autonoma de Santo Domingo
Santiago 22, Santo Domingo
Rep. Dominicana

O.M. JOHANNESSEN
Marine Science Centre
McGill University
Montreal, Canada

F.J. de JOIA
Creole Petroleum Corporation
Apartado 889
Caracas, Venezuela

R. JUHL
G.P.O. Box 4845
San Juan, Puerto Rico 00936

F.A. KALBER
Aquatic Sciences Inc.
2694 N.W. 2nd Ave.
Boca Raton
Florida 33432, U.S.A.

R. KAUFMANN
Instituto Colombo - Aleman de Investigaciones
Cientficas
Apartado Nacional 40
Santa Marta, Colombia

K. KAWAGUCHI
Caribbean Fisheries Development Project, FAO
Kingston, Jamaica

O.E. KERNS
Bumble Bee Seafoods
P.O.Box 30 University Station
Seattle, Washington 98105
U.S.A.

G.L. KESTEVEN
FAO - Oficina Regional para America Latina
Apartado Postal M-10778
Mexico 1, D.F., Mexico

K.L.J. KLEYN
Caribbean Fisheries Development Project, FAO
"The Reef"
Fontabelle, P.O.B. 640 C
Barbados, W.I.

W. LANGERAAR
Rear-Admiral
Hydrographer of the Royal Netherlands Navy
Badhuisweg 171
The Hague, The Netherlands

L.M. LAUZIER
Fisheries Research Board of Canada
St. Andrews, N.B.
Canada

H. LAVIE
Ministerio de Minas e Hidrocarburos
Caracas, Venezuela

B. LETTAU
Sea-Air Interaction Laboratory
U.S. Department of Commerce
Environment Science Services Administration
901 South Miami Avenue
Miami, Florida 33130
U.S.A.

J.B. LEWIS
Marine Sciences Center
Montreal P.Q.
McGill University
Canada

L.B. LIDDLE
Department of Biology
University of Puerto Rico
Rio Piedras P.R. 00931
Puerto Rico

G. LILLY
Bellairs Research Institute of McGill University
St. James
Barbados, W.I.

M.J. LINDNER
Bureau of Commercial Fisheries
Biological Laboratory
Galverston
Texas 77550, U.S.A.

V.J. LINNENBOM
Naval Research Laboratory
Code 8300
4555, Overlook Drive
Washington, D.C. 20390
U.S.A.

M.L. LOPEZ LOPEZ
Urb. Bermudez
Bloque 15-C, Apto. 8-4
Cumaná, Venezuela

H.J. MacGILLAVRY
Geologisch Instituut
Nieuwe Prinsengracht 130
Amsterdam, The Netherlands

J.D. McFADDEN
U.S. Department of Commerce, ESSA/IAS
Research Flight Facility
P.O. Box 197 IAB, Bldg. 2150 MIAD
Miami, Florida 33140
U.S.A.

H.J. McLELLAN
National Science Foundation
Washington, D.C. 20550
U.S.A.

N.J. MALONEY
Instituto Oceanográfico
Universidad de Oriente
Cumaná, Venezuela

C.R. MANN
Atlantic Oceanographic Laboratory
Bedford Institute
Dartmouth, N.S., Canada

N. MARSHALL
Graduate School of Oceanography
University of Rhode Island
Kingston, R.I. 02881
U.S.A.

Y.Y. MARTI
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

R. MARTINEZ ESCARBASSIERE
Proyecto de Investigación de los Recursos
Pesqueros, MAC - FAO
Maracaibo, Venezuela

G.W. MILLER
Fisheries Laboratory
P.O.B. 181
Belize City, British Honduras

P. de Castro MOREIRA DA SILVA
Ministerio da Marinha
Instituto de Pesquisas de Marinha
Rio de Janeiro, Brazil

J.E. MORETTI
Dirección de Hidrografía y Navegación
Observatorio Cagigal
Apartado Postal No. 6745
Caracas, Venezuela

J. MUNRO
Zoology Department
University of West Indies
Kingston 7, Jamaica

V.S. MURAVEISKAIA
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

K.N. NESIS
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

W.D. NESTEROFF
Laboratoire de Geologie Dynamique
Sorbonne
1 Rue Victor-Cousin
Paris 5ème, France

T.M. NICHOLL
Fisheries Officer
Turks & Caicos Island
B.W.I.

M. NIKOLIC
c/o Department of Fisheries, FAO
Via delle Terme di Caracalla
Rome, Italy

D.J.G. NOTA
Department of Regional Soil Science
Agricultural University
P.O. Box 37
Wageningen, The Netherlands

T. OKUDA
Instituto Oceanográfico
Universidad de Oriente
Apartado Postal 94
Cumaná, Venezuela

S.R. OLIVIER
Instituto de Biología Marina
Casilla Correo 175
Playa Grande, Mar del Plata
Argentina

L.B. ORTIZ BORDA
Facultad de Ciencias del Mar
Fundación Universidad de Bogotá
"Jorge Tadeo Lozano"
Calle 23, 4-47 Oficina No. 314
Bogotá, D.E., Colombia

F. OSTAPOFF
ESSA
Atlantic Oceanographic Laboratories
901 South Miami Avenue
Miami, Florida 33130
U.S.A.

T.A. OSTROUMOUA
Institute of Oceanology
Academy of Science of the U.S.S.R.
Moscow, U.S.S.R.

N.V. PARIN
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

P.E. PENCHASZADEH
Instituto de Biología Marina
Casilla de Correo 175
Mar del Plata, Argentina

J. PEREZ
Instituto de Biología Marina
Universidad Autónoma de Santo Domingo
Santiago 22, Santo Domingo
República Dominicana

I. PERLROTH
National Oceanographic Data Center
Washington, D.C. 20390
U.S.A.

M. PINTO PAIVA
Rua Monsenhor Bruno 1569
Fortaleza, Caerá
Brazil

M. PORRAZ
Organización Submarina Mexicana
Balderas 44, 4° Piso
Mexico 1, D.F., Mexico

G. POSEWITZ
División de Planeamiento
Centro Simón Bolívar, Torre Sur
Piso 10
Caracas, Venezuela

F.H. PRIETO
P.R. Economic Development Adm.
313-20th St.
Villa Nevares
San Juan, Puerto Rico 00927

E.C. RACCA
Ministerio Agricultura y Cría
Proyecto Investigación Desarrollo Pesquero
8° Piso Centro Simón Bolívar
Torre Norte
Caracas, Venezuela

C.C. RAMIREZ
Dirección de Geología
Ministerio de Minas e Hidrocarburos
Torre Norte, Piso 19
Caracas, Venezuela

W. RANKE
Institut für Hochseefischerei
Rostock-Marienehe
Democratic Republic of Germany

Th.S. RASS
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
1, Sadovaya Street
Lublino, Moscow Zh. 387, U.S.S.R.

W.F. RATHJEN
Caribbean Fisheries Development Project, FAO
"The Reef"
Fontabelle
P.O. Box 640 C
Barbados, W.I.

E.A. REBAINS
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

R.O. REID
Department of Oceanography
Texas A & M University
Texas, U.S.A.

G. REYES VASQUEZ
Escuela de Biología
Universidad Central de Venezuela
Caracas, Venezuela

C.R. ROBINS
Institute of Marine Sciences
1 Rickenbacker Causeway
Miami, Florida
U.S.A.

G. RODRIGUEZ DEL VILLAR
Dirección de Hidrografía y Navegación
Observatorio Cagigal
Apartado Postal No. 6745
Caracas, Venezuela

N. RORHOLM
University of Rhode Island
Department of Food and Resources Economics
Kingston, Rhode Island 02881
U.S.A.

C.K. ROSS
Atlantic Oceanographic Laboratory
Bedford Institute
Dartmouth, N.S., Canada

ROSSIGNOL
ORSTOM
French Guiana

M. RUIVO
Acting Director
Fishery Resources and Exploitation Division
Department of Fisheries
FAO
Via delle Terme di Caracalla
00100 Rome, Italy

G. SAETERSDAL
Acting Chief
Marine Biology and Environment Branch
Department of Fisheries
FAO
00100 Rome, Italy

J.J. SALAYA AVILA
Ministerio de Agricultura y Cría
Oficina Nacional de Pesca
Caracas, Venezuela

U.S. SAMOILENKO
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

J. SANCHEZ CORTES
Carrera 19 No. 33-75
Apartamento 301
Bogotá, D.E., Colombia

F. SANDER
The Bellairs Research Institute
McGill University
St. James, Barbados, W.I.

E. SCHAEFERS
Bureau of Commercial Fisheries
Room 3351
Interior Building
Washington, D.C. 20140
U.S.A.

W. SCHOTT
Bundesanstalt für Bodenforschung
Hannover-Buchholz
Alfred-Bentz-Haus
Postfach 54
Federal Republic of Germany

C. SCHUBERT
Dirección de Geología
Ministerio de Minas a Hidrocarburos
Caracas, Venezuela

D.P.D. SCOTT, R.N.
Hydrographic Department
Ministry of Defense
Old Mar Office
Whitehall
London S.W. 1, U.K.

E. SEA BROOKE
2235 Hindle Lane
Bowie, Maryland
U.S.A.

J.M. SELLIER DE CIVRIEUX
Instituto Oceanográfico
Universidad de Oriente
Apartado Postal 94
Cumaná, Venezuela

G.I. SEMINA
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

S. SERRA CASTELAN
Departamento de Meteorología
Instituto de Geofísica
Universidad Nacional Autónoma de México
3er. Piso Torre de Ciencias
México 20, D.F., México

D. SILVA LOPEZ
San Borja 908
Depto. 1
México 12, México

O. SILVA SANCHEZ
Centro de Investigaciones Pesqueras
Apdo. 95
Cumaná, Venezuela

J.G. SIMPSON
UN/SF Fisheries Research and Development
Apartado 2578
Caracas, Venezuela

R.H. SIMPSON
Director
National Hurricane Center
P.O. Box 8286
Coral Gables Florida 33124
U.S.A.

P.R. SOLA
P.R. Economic Development Administration
San Juan, Puerto Rico

V.P. SMIELGA
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

H.J. SQUIRES
Marine Fisheries Development Project
c/o FAO Mission in Colombia
Apartado Aereo 17798
Bogotá 1, Colombia

D.M. STEVEN
Zoology Department
McGill University
Montreal 2, Quebec
Canada

L.M.J.U. VAN STRAATEN
Geologisch Instituut
Melkweg 1
Groningen, The Netherlands

J.W. SWINNERTON
Naval Research Laboratory
Code 8300
4555 Overlook Drive
Washington D.C. 20390, U.S.A.

B.J. SZENK
Gulf-Latin America
P.O. Box 910
Coral Gables, Florida 33134
U.S.A.

C. VEITIA
Dirección de Hidrografía y Navegación
Observatorio Cagigal
Apartado Postal No. 6745
Caracas, Venezuela

W. VERVOORT
Rijksmuseum van Natuurlijke Historie
Raamsteeg
Leiden, The Netherlands

A. VILLALOBOS FIGUEROA
Instituto de Biología
Universidad Nacional Autónoma de México
Apartado Postal 70-233
México 20, D.F., México

G.L. VOSS
Institute of Marine Sciences
University of Miami
1 Rickenbacker Causeway
Florida 33149, U.S.A.

P. WAGENAAR HUMMELINCK
Zool. Laboratorium
Janskerkhof 3
Utrecht, The Netherlands

R. WEYL
63 Giessen Landgraf Philipp Platz 4/6
Federal Republic of Germany

R.T. WHITELEATHER
Bureau of Commercial Fisheries
144 1st Avenue South
St. Petersburg
Florida 33704, U.S.A.

D. WHITTINGTON
Oberheim Association
910 17th ST NW
Washington D.C., U.S.A.

J.P. WISE
Bureau of Commercial Fisheries
Tropical Atlantic Biological Laboratory
75 Virginia Beach Drive
Miami, Florida 33149
U.S.A.

H.E. WOOD
Ministry of Agriculture and Fisheries
St. Clair Circle
Port of Spain, Trinidad

L.V. WORTHINGTON
Woods Hole Oceanographic Institution
Woods Hole
Massachussetts 02543, U.S.A.

S. YAKOWSKA
Instituto de Biología Marina
Universidad Autónoma de Santo Domingo
Santiago 22
Santo Domingo, República Dominicana

L.M. ZADORINA
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

J.M. ZEIGLER
Department of Marine Sciences
University of Puerto Rico
Mayaguez, Puerto Rico 00708

L.A. ZENKEVICH
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

G.B. ZEVINA
Institute of Oceanology
Academy of Sciences of the U.S.S.R.
Moscow, U.S.S.R.

E. ZORRI DE ROA
Instituto de Zoología Tropical
Universidad Central de Venezuela
Caracas, Venezuela

ANNEX 2

ADDRESSES AT THE OPENING SESSION

Introductory address by Rear Admiral W. Langeraar, Hydrographer of the Royal Netherlands Navy, Chairman, Intergovernmental Oceanographic Commission

Your Excellency, Governor of the Netherlands Antilles,
Your Excellency, Minister President,
Excellencies, Lieutenant Governor of Curaçao, Commodore,
Senators of the Legislative Assembly of the Netherlands Antilles,
Ladies and Gentlemen,

May I first of all address myself to you, Mr. Governor and express the feelings of gratitude and high satisfaction, on behalf of all present here today, for the fact that you have been willing and able to be amongst us this morning and have graciously consented to welcome us officially and to open this Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions.

Also, on behalf of all participants, I would like to thank through you the Government of the Netherlands Antilles for the deeply appreciated offer to act as host country for this Symposium.

It is thanks to this kind offer that the Symposium will be held this week on the Island of Curaçao, the island of contrast, because
it is Dutch, it is Latin,
it is old, it is new,
it is scenic and it is fun,
a very apt and concise characteristic which, as you may recognize, I have quoted from the folder I found among my conference papers.

I would also like to speak a word of welcome to
His Excellency the Minister President, Minister C.D. Kroon,
His Excellency the Minister of Social and Economic Affairs, Minister J.A.O. Bikker and
His Excellency the Minister of Public Health, Minister E. Voges, as well as to the Lieutenant Governor of Curaçao, Mr. O.R.A. Beaujon, present here today and convey to them our feelings of thankfulness for the continuing interest they have shown in the organization of this Symposium and for the invaluable assistance they have given to the local organizing Committee that has done so very much under the energetic and dedicated leadership of Dr. Creutzberg, Director of the Caribbean Marine Biological Institute.

Speaking in the context of assistance received during the preparation and organization of this meeting and the help that is going to be given during this coming week, our grateful recognition should go out towards the Royal Netherlands Navy and its Senior representative in this country, Commodore Visee, to the Government Information Service, the Cadastral Survey, Shell Curaçao, the Chamber of Commerce and its Junior Chamber the Jaycee's, the Direction of the Curaçao Hilton and the United States Consulate General.

Of course these are only a few examples and I will be excused if I do not give you an exhaustive list of all those who have, in one way or another, contributed to what can be considered as an excellent organization of a very diversified conference. Only one institution I would like to add to my list, an institution of which a number of representatives are in our midst today, i.e. the Legislative Assembly of the Netherlands Antilles, because this Assembly voted in favour of the spending of a considerable sum of money to enable the government to substantiate its offer of hospitality for this Symposium. Though we all are convinced that money is the root of all evil, I am equally convinced that the money spent on this Symposium will have no evil consequences at all, but rather will bear fruits that, when collected, will be beneficial also far outside the Netherlands Antilles.

Further it is my pleasant duty to express our thanks to the specialized Agencies of the United Nations for jointly organizing this Symposium, to the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Food and Agriculture Organization (FAO), with the co-sponsorship of the World Meteorological Organization (WMO).

We are particularly glad that the executive heads of these organizations are represented here today by Dr. Giermann for UNESCO, Dr. Ruivo for FAO and Dr. Bruinenberg for WMO, all of whom will make a short introductive statement later.

As this Symposium is, therefore, held under the auspices of the United Nations System, the flag of the United Nations will be hoisted outside at the moment the Governor of the Netherlands Antilles declares this Symposium opened. The UN flag will fly until the end of the closing session.

May I now dwell on another agency with which I am intimitaly connected, the Intergovernmental Oceanographic Commission (IOC). This Commission was established in 1961 within UNESCO with the purpose to promote scientific investigation with a view to learning more about the nature and resources of the oceans, through the concerted action of its members.

I may draw your attention to the wording of the purpose of the Commission, which I quoted from its Statutes. The IOC is not a pure scientific commission itself but has been created to promote scientific investigation. The IOC should be looked upon as a machinery, and I may add as a successful machinery, through which marine scientists can cooperate in collecting basic data.

By making the collected and evaluated data available to all who are interested, either through world data centres or through regional or national data centres, IOC fulfills an indispensable rôle in the functioning of marine scientific research. This is the more so as a further aim of the Commission is to promote scientific investigation through the concerted action of its members.

This means that IOC is not in the first place interested in national oceanographic research, but rather in marine investigations that, because of their scope and the complexity of modern research, or sometimes the requirement to cover such vast stretches of ocean with simultaneous or synoptic observations, that it becomes impractical and sometimes even impossible for one country, however large, to do this without the help from others.

Now the Intergovernmental Oceanographic Commission during its fifth Session last year approved to organize, coordinate and implement a project that was laid before it through the initiative of the Netherlands Government, a project that since has been named the Cooperative Investigations of the Caribbean and Adjacent Regions (CICAR).

It is with this project in mind that the IOC is highly interested in the outcome of the Symposium from which it expects to receive some firm guidelines for the conception of a comprehensive and well balanced scientific programme for the CICAR project. As chairman of IOC I am, therefore, particularly pleased with this Symposium for several reasons, the least of which may be that IOC was not asked to foot part of the bill.

Nearing the end of this introductory address, may I devote a few words to the organization of the Symposium. What we will need first of all and most of all is a high degree of discipline, that is self-discipline of all those who are going to lecture or present papers. As you will have seen, a review lecture shall not take more than 40 minutes and the presentation of a paper shall not exceed 10 minutes. The presentation of a paper shall NOT consist of reading the whole paper. These time limits unfortunately will have to be adhered to rigorously and the calendar of the meeting should be looked upon as to be given in real time. When doing this we should keep in mind that a number of scientists who present more than one paper, have consented in presenting only one of these, in order to make it possible to hear at least all those who have prepared papers.

The Symposium will consist of four sections:

Section I Physical and Chemical Oceanography,
Section II Marine Geology and Geophysics,
Section III Marine Biology, and
Section IV Fishery Resources.

For each of these sections a chairman has been appointed and I would like to thank them for their willingness to take such an active part in the organization. They are:

for Section I : Dr. J. Emilsson
for Section II : Prof. Dr. H.J. MacGillavry
for Section III : Prof. Dr. A. Ballester
for Section IV : Prof. Dr. C.P. Idyll

It is my suggestion that these chairmen, together with their sections appoint two rapporteurs, one fully conversant in the English, the other in the Spanish language. These rapporteurs should make condensed reports on review lectures and presentations of papers and should, as the work of the section proceeds, prepare draft recommendations for their section. This means they should all be

present during discussion meetings for which a number of rooms are available.

It is left to the discretion of the chairmen whether they will deem it necessary to appoint vice-chairmen to chair over meetings of sub-sections. This may be a profitable way to handle a large section. If this is done, however, it is suggested that again for such a sub-section two rapporteurs are appointed.

Only a short time is available for a General Final Discussion which should lead to the identification of research needs and the adoption of recommendations for CICAR. This means that draft recommendations of all sections must be available at the beginning of the final discussion and should preferably have been approved already in the Section concerned. Much will depend here on the degree of test-work to which participants will be able to rise.

The recommendations adopted will be presented to the three executive heads of the sponsoring agencies and will also be used for the meeting of the International Coordination Group for CICAR that will meet for the first time on Monday 25 and Tuesday 26 November. To this meeting the chairmen of the four sections are invited and their participation in the debate will be gratefully appreciated as they do not only bring the recommendations of their respective sections, but also the history behind each of these recommendations.

For your further information it is good to know that Dr. Hugo Barrales will act as general symposium rapporteur and either he or myself will be at your disposal for further assistance and guidance. It is my sincere conviction that this meeting will become a success the degree of which will also be dependant on the cooperation of all of us. Here, Benjamin Franklin's advice comes to my mind when he said: "Let us hang together, lest we will be hung separately". In this connection, it is worthwhile for you to know that there is a famous flag signal at sea that means: "Let us stay together for mutual assistance". Let me hoist that signal and leave it at the mast until the end of this Symposium.

Opening address by Dr. G. Giermann, Deputy Director, Office of Oceanography, UNESCO

Your Excellency, Excellencies, Mr. President, Ladies and Gentlemen,

It is a great honour and pleasure for me to have this opportunity of bringing to you the greetings of Mr. René Maheu, Director-General of UNESCO, and to welcome you in his name to the first Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions.

At the present time we are all taking part in a new approach to eventual mastery of the hydrosphere. The discovery of "inner space", the exploration and exploitation of our oceans and their adjacent seas, and the solution of the related scientific and technical, economic and legal problems is no more simply a vague desire on the part of mankind but is on the point of being realized. The sea is being discussed more and more in the fora of the United Nations and their great family. The latest UN resolution on "peaceful uses of the sea-bed and ocean floor beyond the limits of national jurisdiction" is a challenge to all of us to collaborate in an endeavour to make the sea and its bed exploitable for the benefit of the whole of mankind. I am happy to say that UNESCO and the Intergovernmental Oceanographic Commission have been pursuing this aim for the past ten years. We have held symposia in various regions of the world but it is the first time that we are holding one in the Caribbean area.

This Symposium was conceived at the Fifth Session of the Intergovernmental Oceanographic Commission when the Netherlands presented for the Commission's approval a proposal for cooperative investigations in the region. This found wide support both among the IOC members and outside IOC. The Commission also established the International Coordination Group for Cooperative Investigations in the Caribbean and Adjacent Regions which would use the findings of the Symposium to formulate plans for the cooperative investigations. Eleven countries - Cuba, the Federal Republic of Germany, France, Guatemala, Jamaica, Mexico, the Netherlands, the United Kingdom, the United States, USSR, and Venezuela - have so far applied for membership in the Coordination Group. The Food and Agriculture Organization of the United Nations and the World Meteorological Organization promised their collaboration with UNESCO in the project and the Netherlands Antilles offered to host the Symposium in Curaçao. So here we are today at the opening of a Symposium which, I am sure, will be both interesting in itself and promising for the future of the region and the development of oceanographic research in general.

The purpose of our Symposium is to review knowledge, identify gaps in the various fields of marine science and resources research and to initiate the planning and conduct of cooperative investigations of the Caribbean and its adjacent regions. You, the scientists present here, are therefore asked not only to discuss completed works but also to initiate ideas for the new scientific programme for the cooperative study of the area. As representative of the IOC Secretariat, I should very much appreciate it if this Symposium's final general discussion could lead to acceptance of a list of recommendations to guide the discussions of the CICAR Coordination Group which will start its work immediately following the Symposium. We hope that the 140 lectures and papers of this Symposium on physical and chemical oceanography, marine geology and geophysics, biology and fishery resources, will give you useful background information, thus facilitating elaboration of your proposals.

In closing, may I take this opportunity to express on behalf of the Director-General of UNESCO our sincere appreciation and gratitude to our hosts and to the Local Organizing Committee under the capable leadership of Dr. Creutzberg, and to our co-sponsoring agencies FAO and WMO for their close and fruitful collaboration. Last, but by no means least, I should like to thank all of you who have come here to contribute in such large measure to our knowledge of the sea and its resources. I wish the Symposium every success.

Opening address by Dr. M. Ruivo, Acting Director, Fishery Resources and Exploitation Division, Department of Fisheries, FAO

Your Excellency, Governor of Netherlands Antilles,
Excellencies, Mr. Chairman, Fellow Scientists and Colleagues,

It is a great privilege and pleasure to address this Symposium on behalf of FAO. I bring with me very cordial greetings from the Director-General, Mr. Addeke Boerma. He asked me, in particular, to express the Organization's appreciation and gratitude to the Government of the Netherlands Antilles for all facilities offered to host the Symposium. Mr. Roy I. Jackson, Assistant Director-General (Fisheries), has also requested me to convey to you his best wishes for a successful meeting, the results of which we are awaiting with great expectation, in view of the importance the Department of Fisheries attaches to this area.

This is the third of a series of Symposia jointly organized by UNESCO and FAO in support of cooperative investigations undertaken under the aegis of the Intergovernmental Oceanographic Commission (IOC) and we were very pleased that also WMO decided to participate in this one. Even if apparently they are similar in scope, a careful analysis shows a positive trend in the way international cooperative investigations are being organized and how UN specialized agencies are coordinating their efforts and developing joint action in the field of marine science and its applications. In fact, both the Symposia in Abidjan (Ivory Coast, 1966) and Honolulu (U.S.A., 1968) were convened to review, respectively, the results of the International Cooperative Investigation of the Tropical Atlantic (ICITA), the Guinean Trawling Survey (GTS) and of the Cooperative Study of the Kuroshio, in each case after the termination of the sea-work or when it was already in progress.

The present Symposium has, however, the specific purpose of facilitating advanced planning of the Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR), as well as improving scientific cooperation and the rational use of marine resources in the same area. It also shows a deliberate attempt to promote an integrated approach to the study of oceans, encompassing all aspects of marine sciences, and meteorology, as part of a global scientific strategy which requires an overall programme mutually agreed, rather than the mere juxtaposition of national and disciplinary programmes as, for example, was the case of the International Indian Ocean Expedition (IIOE). This approach was certainly in the mind of the promoters of the UN General Assembly Resolution 2172 on the Resources of the Sea, and is in agreement with the ideas expressed in the report and proposals on Marine Sciences and Technology put forward by the UN Secretary-General, particularly those regarding an expanded programme of international cooperation to assist in a better understanding of the marine environment through science, and in the related proposal for an International Decade of Ocean Exploration. FAO, directly, and through its Committee on Fisheries (COFI) and its Advisory Committee on Marine Resources Research (ACMRR) has been actively involved in the implementation of Resolution 2172 and, jointly with the other specialized agencies concerned, in various actions required for its implementation, particularly those dealing with the adaptation of international machinery - both governmental and non-governmental - to these new demands. The part to be played by scientists acting in their individual capacity, either through permanent arrangements (such as ACMRR, SCOR and other bodies, e.g. ICSU) or ad hoc arrangements like this Symposium, is to increase. In the same way, other actions are needed at governmental level, and in this regard, important steps have already been taken through the agreement between the FAO and UNESCO Directors-General to bring about closer collaboration in promoting world ocean research, which included the establishment of a post for an FAO Marine Science and Fishery Coordinator with UNESCO, based in the Office of Oceanography in Paris, whose functions include assistance to IOC secretariat on matters of common interest. A further - and even more important step to facilitate the implementation of the UN Resolution 2172 - may result from the agreement reached during consultations among representatives of the IOC Bureau, UNESCO, FAO, WMO, ACMRR and SCOR, to broaden the basis of IOC and to strengthen it through closer links with other interested agencies (particularly FAO and WMO), so as to further its rôle in the formulation and coordination of the expanded programme to include scientific research and related service activities not only concerning the ocean itself but also its boundaries and resources.

I think I can safely say that, at present, FAO is responsible for activities falling within the scope of the General Assembly Resolution 2172, of the order of 2 million dollars annually in the Regular Programme expenditures; in addition, FAO executes marine field projects under UNDP, and to a lesser extent from other international sources of funds, to a total annual budget of the order of 10 million dollars (exoluding counterpart funds), the greater part of which is attributable to marine scientific and technological activities, including the surveying and appraisal of fishery resources and related oceanographic and other environmental research.

This is a logical situation, if one recognizes that in promoting fishery development and management of the resources, both in the case of developed as well as of developing countries - the application in large scale of science and technology is one essential element. Just as an example, I would like to mention that the planning and conduct of fishery operations on a world-wide scale, with very mobile fleets, make it necessary to increase efficiency, and, therefore, to develop forecast services of environmental conditions and of distribution and abundance of resources. Equally, the exploitation of unconventional resources, or of underexploited resources, usually located in areas of direct interest to developing countries can be better performed if more sophisticated methods - for example, large-scale acoustic echo surveys - are used. In both cases a great deal of information on ocean conditions - including such meteorological products as those to be provided by the World Weather Watch - is to be expected from the International Global Observation Service System (IGOSS) for which IOC is now making preparation - and is needed as an element for better interpretation of results of fishery research.

The "World Appraisal of Fishery Resources" (a section of which will be devoted to the Caribbean area) within the framework of the FAO Indicative World Plan for Agricultural Development (IWP), under which projections are being made of fish yields, by 1975 and 1985, is being developed under the general guidance of ACMRR, using various methods, including estimations based on turnover rates and available data on the primary production in the area under review. A great effort is also being made to improve the basic fishery statistics which are essential for this type of study. I think I should mention here that in this work FAO is collaborating quite closely with other international and with national institutions. It is the intention of FAO's Director-General to channel and concentrate a great deal of the Organization's future efforts on a few major programme objectives, selected as the most likely to be fruitful in yielding practical results over the next decade or so. The fields selected are five, two of which - "Closing the Protein Gap" and "War on Waste" - are central to the main thrust of all our work in the field of fisheries and others - "Increasing Foreign Exchange" and "Utilization of Human Resources" - are pertinent to some aspects of fishery research or development.

With these objectives in mind, a series of extensive programmes are being implemented or will be launched as part of national fishery development projects with financial aid of the UNDP/SF and TA for which FAO is the executing agency.

The main emphasis of these programmes is on the evaluation of the available resources, and the work comprises both exploratory fishing and investigation of the biology of species of commercial value and the state of stocks, and their reaction to fishing and environmental conditions. Projects of this type have recently been started in Venezuela and Colombia, and two joint regional schemes are being carried out: the Central American states and the Caribbean islands project. In Mexico a project is expected to become operational in the near future, and a new project in Brazil, with some relevance to the Caribbean area, is contemplated.

About 50 internationally recruited specialists in various fields of fishery science and technology will be involved and about double that number of local counterpart experts. Nine fishery research or exploratory vessels will be engaged in various types of operations. The total cost of these projects will be around 20 million dollars.

One of FAO's interests in this Symposium and in CICAR is based on the certainty that these projects can be of great value to fishery research activities in the area, and, in return, our fishery research teams and facilities could contribute in no small measure to their success.

In this regard, I should mention that the FAO Conference on the Biology and Culture of Shrimps and Prawns (Mexico, 1967) - pointing out once again that international cooperation is required to make more effective the rational exploitation and conservation of marine resources in a given area - recommended that FAO should explore the possibility of adopting pertinent measures to facilitate regional cooperation in the Caribbean area. This proposal was given preliminary consideration by governing bodies of FAO, but it was decided to have the benefit of the results of this Symposium and of your deliberations before going further. Meanwhile, as requested by the Conference, we have adopted some intermediate actions or ad hoc arrangements, of which this Symposium is an example. As I have already mentioned, FAO also has underway a considerable number of field projects in the area and a coordinating meeting of our field staff will be held in conjunction with this Symposium.

It is my earnest hope that you will find some of these observations timely and helpful as a background for your discussions and conclusions.

In closing, may I ask you to present to the Government of the Netherlands Antilles the gratitude of the Director-General of FAO for the hospitality extended to this Symposium and to express once again the pleasure of cooperating with our sister agencies UNESCO and WMO in support of IOC.

Opening address by Dr. A. Bruinenberg, Director, Department of Meteorology, Netherlands Antilles

Your Excellency, Excellencies, Mr. Lt. Governor, Mr. President,
Ladies and Gentlemen,

The Secretary-General of the World Meteorological Organization, Mr. Davis, has entrusted me with the difficult task of representing him in the first meeting of the International Coordinating Group for the project which is known as the Cooperative Investigation of the Caribbean Sea and Adjacent Regions. He also asked me to represent WMO in the Symposium leading up to this meeting of the Coordinating Group.

In acting as such, I want to associate myself with earlier speakers in welcoming you all to this Symposium.

On behalf of the Secretary-General, I want to express his appreciation to UNESCO and FAO for the invitation extended to WMO to participate in these meetings. He welcomes very much indeed a further collaboration of WMO with these sister organizations, to be focused now on the Caribbean Area.

For a meteorologist, the weather in the vicinity of Curaçao may sometimes seem dull, but this, in general, is not true for the Caribbean as a whole. In summer, many tropical disturbances affect the area, some of which will deepen to tropical storms, or will even reach maturity as full hurricans. These hurricans which are formed over the mid-Atlantic Ocean and the Caribbean Sea and which obtain their energy from the water do - in a later stage - affect the ocean surface in a considerable extent. In this respect I may mention the efforts of the U.S. Weather Bureau which started a large research programme on hurricans in 1956, in which several small countries and territories in the Caribbean were invited to cooperate.

The National Hurricans Research Laboratory and the National Hurricans Centre at Coral Cables, Florida, have produced excellent reports on this research. It goes without saying that air-sea interaction plays an important rôle in these studies.

Several institutes and universities in countries in and around the Caribbean have contributed to the present knowledge of the interaction between sea and air and I am pleased to notice some experts in this field among the participants.

To the tools, available for meteorologists a new one was added 10 years ago when the first meteorological satellite was brought into orbit. The progress made during the following 10 years in the further development of these sophisticated observation and communication platforms as well as in their applicants are most fascinating.

It is likely that already during the CICAR-project the measurement of sea-surface temperatures with an acceptable accuracy will become a routine operational matter.

It is further hoped, that the CICAR-project will profit from that daring, world-wide plan of WMO, known as WORLD WEATHER WATCH. In this plan, all countries around the world are urged to improve the quality of their observations, to increase the network of observations to fit into the global network and to stimulate research. Member countries of WMO are invited to contribute to the voluntary Implementation Programme through which - ultimately - the plans for global observing, date processing and telecommunication systems shall materialize.

Ladies and Gentlemen, WMO wishes to cooperate - where possible and practicable - with other organizations in making the CICAR-project a success. But in order to give this project a sound base we depend on you, scientists gathered here; through your lectures and by fruitful discussions which we hope will follow, it should be possible to formulate the necessary recommendations by the end of this week; recommendations which should clearly outline on which sections in each scientific field of the CICAR-project the activities should be concentrated on.

I am very well aware of the fact that a heavy programme is waiting you in the next five days, but I trust that the favourable outcome of your deliberations will reward you and will justify your exertion.

On behalf of the Secretary-General of the WMO, I wish you all possible success in your endeavours.

Opening address by Dr. N. Debrot, Governor of the Netherlands Antilles

Excellencies, Very distinguished Guests and Hosts,
Ladies and Gentlemen,

It is an honour and a great pleasure for me to welcome you on behalf of the Government and people of the Netherlands Antilles at the beginning of this exceptional Symposium that is being held under the auspices of three specialized organizations of the United Nations, the UNESCO, the WMO, and the FAO. We are more than happy to have you as our guests and to offer you every facility possible to make your stay on our island as agreeable and restful as possible. I am convinced that the discussions which will take place during the Symposium will also be continued after you have returned to your own countries as a result of the friendly relations entered upon while here.

It has been said that we live in a time of transition. I believe that we can all agree with this opinion, if we also keep in mind that all historical periods can be looked upon as times of transition. For in whatever time we may live, we always find ourselves somewhere between the hazy past and the - in many respects - not less hazy future. Contemporaries have the tendency to view their time as a period of transition because it appears in so many different shapes and displays such a variety of aspects that it hardly lends itself to a naive or simple characterization. Some have attempted to place the various and often very divergent aspects of our time under one and the same denominator. It has, among other things, been called a period of accelerated evalution. The argument for this is to be found in the many changes that have taken place and still are taking place in all the fields of human activity. We have only to think of the great changes which have occurred in politics, economics and sociology. Without a doubt, the accelerated evolution is one of the hall marks of our time. Another is surely to be found in technique because it becomes increasingly clear that the machines of the nineteenth century are being replaced by the electronics of our century. We all know that one of the most specific features is also sought in the new communication mediums, especially in radio and television. The Canadian professor Marshall McLuhan has gone so far as to put forth the theory: "The Medium is the message". Opponents of McLuhan may call this theory McLuhanacy, but that does not change the fact that the professor is right insofar as the telecommunication, that is, the medium has influenced the message to an important degree.

We could mention many other striking aspects of our time. Personally I would like to emphasize the pragmatic nature of our era. The scientific research and experiments of the nineteenth century are being continued in this century, but their significance now is no longer to be found within themselves or in the facts involved in the research. Instead their significance and value lie in the programmatic employment of service to mankind and especially to the countries and people in the stage of development. The pragmatic trend of our science is obvious in the research of oceanographers. This Symposium is taking place under the auspices of three specialized organizations, which undoubtedly have a scientific basis, though they really pursue practical purposes, respectively, a raising of the level in the field of pedagogy, meteorology and the organization of agriculture and food supplies. The dual nature of this Symposium stands out in its name: "Investigations and Resources of the Caribbean Sea and Adjacent Regions". If I am not mistaken, your Symposium will apply itself especially to research that can lead to the tapping of new sources of aid in the Caribbean and its surroundings with the aim to help, alleviate, and solve the food problem in the region itself and thereby also in the world - a world surely in need! We can do no less than heil your efforts. An optimal supply of materials is in any case one of the most important factors that can contribute to the well-being of mankind. We cannot live from bread alone, but it is good to remember that without bread or similar food we cannot live at all. Moreover, the willingness to help must be seen as a commandment that can be found in every real religious or ideological experience, the commandment to love thy neighbour or, to speak in modern terms, to lend technical or financial assistance. This holds even more in a time when, because of the population explosion, there is a steady increase in the needs and when we realize more and more thoroughly that the supply of material necessities is not always judiciously determined and conducted, with the result that the appearance of many countries and regions has undergone a radical change and many sources have completely disappeared or have fallen behind in production capacity.

This leads as a matter of course to the search for other sources and in this connection scientists have turned their attention to the immeasurable riches of the sea. President Kennedy once declared in Congress: "A knowledge of the ocean is more than mere curiosity. Perhaps the continuance of our survival depends on it". It is known to you that some experts have expressed this idea in more positive terms. It is, therefore, highly praiseworthy that this research, aimed at a greater knowledge of the seas and oceans takes place on an international level so that all those who have a potential right to participate - and that means in principle all people without exception - can equally make use of the results in order to obtain their portion of the fauna and flora of the sea.

The sea is still in many respects a strange element for mankind. "Water, water, water galore, everywhere water..." that is how our planet looks to the astronauts who circle around it in space. And that is understandable! Nearly three quarters of the earth's circumference is covered with water. We do not realize that we live on a planet which some scholars call a water planet. We realize even less that our knowledge about our own planet, the water planet, is considerably less than our knowledge of conditions on our satelite, the moon.

The participants of the Oceanographic Symposium gathered here this morning must without any hesitation be counted among the pioneers of modern times. Just as all pioneers they live in a milieu that lodges many mysteries and besides many dangers also many possibilities for our future!

A great part of our hope for the future of mankind has been fixed on you. I believe I can also say that in this respect you have our fullest confidence, which I hope may be a moral support in your work. You will be happy with the fact that you are better prepared for your task than former pioneers. Thanks to the many many years of research and experience that lie behind you, the most modern facilities will be at your disposal.

We wish you the greatest success in your wide-spread endeavours and we are looking forward to the results in the setting up of the foundation for a better future for mankind, of which certain elements are growing under your guidance.

ANNEX 3.

INTRODUCTORY LECTURE

A REVIEW OF RESEARCH AND EXPLORATION IN THE CARIBBEAN SEA AND ADJACENT WATERS*

by

Frederick M. Bayer

Institute of Marine Sciences, University of Miami

*Contribution No. 1127 from the School of Marine and Atmospheric Sciences, University of Miami.

Fig. 1 Western part of the Cantino Map. Reproduced by courtesy of the Director, Biblioteca Estense, Modena.

1. INTRODUCTION

"With regard to those colonies of New Spain and Peru and the other regions comprised in the New World, as large as the three of the Old World of Europe, Asia, and Africa, there was no word or trace until, in the year 1492, the renowned Don Cristobal Colon made a beginning of his discoveries, and in so doing underwent great risks and excessive difficulties - the world's foremost achievement, for which it ought to be called Colonia ..." So wrote Antonio Vázquez de Espinosa in 1629 (Vázquez de Espinosa, 1942, Chapter V, paragraph 24, p. 10). Regardless of the evidence obtained by careful historical, cartographic and archaeological research to show the presence of European seafarers in the New World long before Columbus, our recorded knowledge begins, to all intents and purposes, with Columbus' landfall on October 11-12, 1492. With this date the history of exploration, investigation and research upon the Caribbean Sea begins.

Before proceeding farther, it should be pointed out that a review of exploration and research in the Caribbean is a rather large undertaking and too broad a subject to be covered exhaustively in the space available. As the general facts are so familiar that repetition would be superfluous, it seemed more interesting to follow some of the less well known historical byways. Moreover, as a biologist I must apologize for overemphasizing the natural sciences in this survey, but it is this field that has received the greatest attention in the Caribbean.

In taking the broad view of explorations in the Caribbean area, rather than the narrow view of strictly "scientific" exploration, advances in knowledge may be divided into four historical periods:

(1) Pre-Columbian, beginning at any time the evidence becomes credible and ending about the middle of the 15th Century when all the rumored murmurings of a New World to the west could be ignored no longer;

(2) The period of geographical exploration, motivated by religious zeal and the quest for wealth, territory and power, lasting for some three centuries down to the middle of the 18th; then a transitional century followed by:

(3) A Century of Scientific Exploration, 1850-1950; and, finally,

(4) A period of modern, intensive, and increasingly synoptic research.

How shall we define the "Caribbean and adjacent areas"? Early explorations were not confined within the Caribbean boundaries - the arc of Antillean islands and the coasts of Central and South America - any more than are scientific explorations of the present day, any more than are the waters and the animals and plants living in them. The only natural boundaries are set by the animals and plants. If we accept their indications, we should include on the north the Gulf of Mexico, the Straits of Florida and Bahama Banks and, justifiably, Bermuda, "The Summer Isles." On the south, about 1,000 miles of the South American shoreline at least as far as the mouth of the Amazon are occupied by an essentially Caribbean marine fauna. Over this whole area range numerous important animal resources such as the various species of commercial shrimp and lobster, many other shellfish, food fishes, and sea turtles. Even though their populations may be concentrated in one region or another, still this broad Caribbean area forms the zoogeographic range of many species. Upon sampling the deeper waters, an even greater uniformity of distribution is evident, and the composition of local populations reflects the surrounding ecological situations more than it does any major zoogeographic divisions. In certain depth, on certain kinds of bottom, we know that we can safely predict the presence of certain kinds of animals. There are, of course, many examples of strictly limited distributions and any small geographical area will contain its faunal peculiarities, but these should not alter the picture overall.

Having drawn the battlefield, as it were, we now can proceed to summarize the campaigns that have taken place on it.

2. PRE-COLUMBIAN EXPLORATIONS

Even though men commenced to set down and record for posterity their feats of geographical daring only after 1492, to be fair to those whose names are now forgotten but who, before Columbus, underwent - perhaps unintentionally - even greater risks and more excessive difficulties and thereby stumbled upon the vast New World, let me again quote the world of Fray Antonio (even though he seems to have forgotten his previous pronouncement): "The Andalusian pilot who was trading among the Canary Islands and got carried off by another storm to the discovery of the Indies, by name Alonso Sanchez, ... about the year 1480, had such ill fortune that through his death, the result of the trials undergone

in the storm and the exploration he carried out, he was unable to leave his name immortalized, but he left to the renowned Christopher Columbus for his kind hospitality the journals and notes which he had kept on the voyage, by virtue of which Columbus later made the great discovery of the Indies." (Vázquez de Espinosa, 1942, Chapter VI, paragraph 29, page 12.)

Surely, this was not a single seafarer and not a single discovery for, as Kohl (1862 p.2) pointed out more than a century ago, "In the disclosure of the American continent there was a long dawn. For centuries was America, so to say, like an ignis fatuus dancing before the eyes of the world, now and then faintly glimmering, then again vanishing into darkness, until at last Columbus and his followers held it fast, as it were, and made it cast anchor." Moreover, Kohl recounts the suggestion that Phoenecians may have crossed the Atlantic at a very early date and perhaps maintained a regular commerce with the Antilles and Central America (1862, p. 9). In any case, sailors were venturing from the Mediterranean out into the Atlantic both along the coast of Europe to the north and Africa to the south long before Columbus. The Canary Islands were visited by Genoese expeditions between 1275 and 1304, and by the Spanish as early as 1326; and Portuguese seamen reached Madeira about 1420, the Azores in 1432, and the Cape Verde in 1446. The Canary Islands and Madeira appear on a map of 1339. Another map, clearly dated 1424, which has been studied painstakingly by Cortesão, definitely shows islands in the western part of the Atlantic which are called "Antilia" and represent "the first cartographic representation of the forefront of Eastern America" (Cortesão, 1953). Perhaps the greatest difference between the forgotten Atlantic crossings of the earlier, storm-driven navigators and that of Columbus was one of purpose and determination. It was no storm-swept accident that brought Columbus to America and made October 12, 1492, the starting point for knowledge of the New World.

When we look at a modern map of the winds and currents of the Atlantic in the light of the extent of maritime activity along the Iberian Peninsula and northwest coast of Africa during the late 14th and early 15th centuries, the mystery is why the discovery of the New World came so late. Quite obviously, it was not as late as we once thought even if we discount the early wanderings of the Norsemen in the North Atlantic. It is very likely that the failure of the earlier geographical discoveries to gain recognition can be explained at least in part by the fact that manuscript records were for the most part unique. Printing had not yet been invented to give them wide distribution and insure them against loss.

3. PERIOD OF GEOGRAPHICAL EXPLORATION

We are concerned in these meetings not only with basic knowledge but also with pragmatic knowledge. It is not at all surprising that the earliest recorded information about the New World - about the Indies and Terra Firma - was of a highly pragmatic nature. This was due less to the primitive state of science in the late Middle Ages and Renaissance than to the vital necessity of recording facts having a high survival value to explorers whose vessels were of the most primitive nature and agonizingly slow, whose equipment and supplies were barely adequate for a round trip when stores could be replenished in the new land. The direction and season of the tradewinds and the set of the ocean currents were essential to a successful passage and a safe return home. Knowledge of the qualities of plants and animals that could be eaten or used in some other way, or that were harmful in some fashion, of the attitude and appearance of the indigenous peoples, could mean the difference between dying in America or returning safely home to hearth and family in Europe. These were the things that were important to remember, important to report to the Crown, important to write about and publish. Everywhere we look in the ancient narratives and voyages we find references to the weather and currents, to sailing routes, to the temper of the natives, and to local natural history.

Certain details of the New World, including part of the Gulf of Mexico and West Florida appear for the first time on the Cantino map of the world. Morison (1940) discusses the evidence for identifying the various places shown on this map, which is estimated to date from about 1500. The western part of the Cantino map is shown in Figure 1, taken from a reproduction kindly supplied by Dr. Eugenia Montanaro Gallitelli of the University of Modena, Italy.

Printed accounts of the explorations of the 15th and 16th centuries are primarily journalistic narratives of the voyages, with incidental observations of oceanic phenomena such as winds, waves and currents, navigational land marks, and natural history - the latter emphasizing the land animals and plants but occasionally mentioning fishes and other marine forms. Gonzalo Fernandez de Oviedo began a new phase and gave us the first comprehensive report on the natural history of the new lands in the Caribbean area. He wrote two important books, the "General and Natural History of the Indies" (1535, 1557) and the "Natural History of the West Indies" (1526). The latter, often referred to as a summary of the former and larger work is, however, a separate and distinct book dealing with the natural and social history of the Indians of Hispaniola and Terra Firma rather than with the political history which forms the subject of the larger work.

The "Natural History of the West Indies" is a remarkable book. Published in Toledo in 1526, it is a brilliant account of the flora, fauna, geography, folklore, and customs of the natives of the Caribbean area - chiefly Hispaniola and Panama, where Oviedo had traveled personally. This eyewitness account of the wonders across the sea was immediately popular in Europe and enjoyed a wide reputation. Many writers obtained from it their principal knowledge of the New World, and armchair geographers and historians were quick to seize upon it as a source of information about places and things they had never seen but wished to write about anyway. It is said that Oviedo's "Natural History" was one of the books that influenced Raleigh in his effort to establish a colony in America. This book is the first to describe many of the wonders of the New World. Here can be found colorful descriptions of many of the plants, land animals, and fishes that are now well known to many Americans and some of them to people around the world. Oviedo's observations on marine animals do not occupy a large part of the Natural History, but their early date gives them considerable importance in the history of marine science. Chapter 83 is an extensive section on fishes and fishing wherein we find mention of several fishes that can be identified tentatively today, such as the mojarra (Eugerres plumieri), biajaca (Serranus inermis), jurel (Caranx latus), pompano (Trachinotus spp.) and others. Oviedo also mentions lobsters, crabs, oysters and very large turtles. He devotes considerable space to the turtle, the shark, and the manatee. He says "There are many other fish and so many species and such a large quantity of them that it would require great space and time to describe them." "Above I promised to describe other fish that are caught while ships are under sail. Among the many good fish caught in the sea are the tunnies. They are large and good and are caught by throwing gigs or harpoons into them as they swim near the ships. In the same way the dolphin, one of the best, is caught." His remarks about flying fishes and their habits are most colorful: "Now I must speak of flying fish, really a wonderful sight to behold. As ships sail the Atlantic they often encounter many flying fish, the largest being as large or larger than sardines and there are smaller ones. Sometimes they rise in such great numbers that it is a wonder to behold, and again there are only a few. They often fly one hundred paces or more, and frequently they fall in the ships. I remember one night that all on board our ship were kneeling on the after deck singing the Salve Regina, when a number of these flying fish rose out of the sea, and many of them fell in our ship. Two or three fell near me, and I held them in my hand and was able to examine them carefully. They were about the size of sardines, and from each side grows a fin as long as the fish, and with these they fly. When these fish rise from the water, they can fly until they become dry. When they dry in the air, they fall again into the water." "

The "Natural History" also contains descriptions of sea birds such as the tropic bird, man-of-war bird, booby, petrel, cormorant and pelican. Among the invertebrates, Oviedo specifically describes crabs, which must have been Cardisoma, and mentions their value as food as well as their poisonous properties when they have been feeding on manchineel apples. Oviedo gave an extensive description of the pearl fishery both in the Caribbean and in the "South Sea," mentioned the most important locations of pearl banks, the abundance of pearl oysters, and the methods used by the natives in pearl diving. He also found that the Indians moved on to other grounds when one became fished out, returning only after the oysters had had time to repopulate the area.

Oviedo was a remarkable man. Born in Madrid in 1478, he was familiar at court from the age of 13 and served as an aid to Prince John. He met Christopher Columbus in 1490, and came to be quite friendly with his sons. As a young man he fought in Italy and Sicily and traveled over most of Europe. He crossed the Atlantic 12 times, fought the natives and explored the jungles of the New World, served the Crown faithfully for more than 50 years, and still found time to be an author of note. The "Natural History of the West Indies" is one of the most fascinating books of the age of exploration.

Richard Hakluyt even as late as 1585 felt it necessary to urge expeditions to America to take along a skillful painter "to bring the description of all beasts, birds, fishes, trees, townes, etc." after the manner of the Spanish practice, but it is not known when an artist was first taken on an English voyage overseas. Francis Drake always had drawn, or himself drew, sketches of strange plants and animals, natives, and happenings during his voyages. Nuno da Silva, a Portuguese pilot, said that "Francis Drake kept a book in which he entered his navigation and in which he delineated birds, trees and sea-lions. He is adept in painting and has with him a boy a relative of his, who is a great painter. When they both shut themselves up in his cabin they were always painting."

Even though captains might in this manner record sketches of the curiosities that they saw, and pilots, especially, recorded in their logs drawings of distinctive coastal features and profiles, landmarks and harbors which were important aids to navigation, the presence of a skilled artist on the early voyages of exploration was quite exceptional. John White is an exceptional figure in the exploration of the New World. He visited America five times. He departed for Virginia on the ship "Tiger" out of Plymouth on April 9, 1585. This voyage to America went by way of the Caribbean, where White drew profiles of the islands of Dominica and St. Croix, and places and events in Puerto Rico.

There and in Hispaniola he collected specimens and drew several plants and fruits, crustaceans, insects and reptiles. It seems likely that the paintings of flamingo, sea birds, and tropical fishes were made in the Bahamas and during his passage through the "Florida Channel." White was skillful in depicting the fish and reptiles,and was quite good with insects and crustaceans as well as birds. John White was the first traveler to depict for us the plants and animals, the natives and the scenery of the southern coast of North America, but is is not this alone that gives him claim to remembrance. He has also a substantial claim to be the first to make a North American contribution to the great Renaissance achievement of exploring, identifying and recording the flora and fauna of the planet, an achievement which was a major element in the establishment of the scientific outlook and the making of modern man (Holton and Quinn, 1964).

As a matter of academic curiosity, it would be most interesting to discover the identity of the first tropical American marine specimen to be brought back to Europe and described in the scientific literature. Nearly all accounts of the earlier voyages contained more or less vivid descriptions of the flora and fauna of the Caribbean. As these mostly were prompted by practical considerations, they typically dealt with the more conspicuous forms on the land, but fishes and other marine animals occasionally were mentioned. Oviedo's "Natural History" of 1526 mentioned a number of marine animals that can be identified with a good degree of probability, but these were descriptions mostly from memory and it is unlikely that any specimens were involved. Furthermore, John White's clearly recognizable drawings of fishes and crustaceans were made around 1585, but were not published until recent times. It is safe to assume, however, that the West Indian voyage of the 16th and 17th centuries did take back to Europe many specimens of the more durable sort. Although difficulties of preservation must have precluded the collection of most soft-bodied organisms, sponges, corals, seashells, the exoskeletons of many crustaceans and certain hard parts of some vertebrates all made passable or even excellent curios. We can easily imagine that corals and shells traveled homewith the explorers even from the earliest voyages, and, as travel became more frequent and more certain, increasing numbers of specimens found their way into curiosity cabinets of princes, noblemen and other wealthy collectors and were described by the well known contemporary naturalists. Many books describing miscellaneous novelties and private museums collections appeared during the 16th, and especially the 17th century. For the most part it is impossible to determine from them the exact origin of specimens, and gross errors commonly arose through faulty memories and misinformation. In the illustrated works, however, the figures of the more distinctive forms clearly indicate where the specimens came from. Among the earliest published descriptions with an identifiable picture of a New World marine animal is that of Manicina areolata (Linnaeus), a common reef coral, to be found in Clusius' Exoticorum Libri Decem of 1605, which contains also pictures of the sea fan and other gorgonians, sponges, fishes, and manatee from the Caribbean area. Cerutus (1622), Jonston (1650), Worm (1655), Olearius (1674) and several other authors of the same period likewise describe and illustrate corals, gorgonians, shells, crustaceans and fishes from the New World, not infrequently copying pictures from one another.

Works of this type continued to appear through the 18th Century, becoming more sumptuous and more exact with the passage of time, so that we can recognize in them many Caribbean sea animals even though we will never know when and where most of them were collected.

Although the 18th Century produced a large number of works describing the natural history of various places in the Caribbean area, these usually did no more than to augment the growing number of known species and to redescribe many that already had been described in an unrecognizable way. Some of the areas covered are Barbados (Sloane, 1707, 1725; Hughes, 1750); Jamaica (Sloane, 1707, 1725; Browne, 1756); Cuba (Parra, 1787); Guiana (Barrère, 1741; Pistorius, 1763; Fermin 1765; Bancroft, 1769; Hartsinck, 1770; Stedman, 1796); Florida (Romans, 1775); and Bahamas (Catesby, 1731-43). A notable exception is Sir Hans Sloane, the founder of the British Museum, whose book on the natural history of Jamaica is an outstanding contribution to our knowledge of the Caribbean. His observations, which cover a wide range of subjects, were careful and his conclusions cautious. His account of the Portuguese Man-of-War (Physalia) can be taken as an example: "This floated on the surface of the water, and consisted of two parts, the one was an oblong cylindrical bladder not so big as a turkey egg, it was as it were blown up and full of wind, almost like the swim of a fish, widest at bottom and grew straighter or narrower to its top, where round about was a corrugated or curled ledge or band, something like a cockscomb, convex on one side and concave on the other, which seamen said was for its more convenient sailing; all this part of it was of a purple and blueish colour and pellucid; the other part of it was a great number of blackish and red fibres, strings or cirrhi; they were long and white, here and there purple, having several knots like nits on it, taking their origin from the bottom of this bladder, which if stretched were several feet long, but if curled up were very short, stinging much worse than nettles, whence it is by some reckoned poisonous. They are very often to be met with at sea, and seamen do affirm that they have great skill in sailing, managing their bladder or sail with judgment, as may be most for their purpose, according to their different winds and courses: allowing them more reason than I, at present, am willing to do of life, there appearing to me no other

parts than the bladder and cirrhi above mentioned."

Among the most important contributions to American natural history during this period were those made by a naturalist about whom the only familiar fact is his name - Mark Catesby. This gifted observer and talented artist, whose background remained obscure for 200 years, spent two sojourns in America early in the 18th century. The first was of some ten years duration in the vicinity of Virginia, and the second in South Carolina, Georgia and Tennessee. During the second stay, Catesby made a side trip of some months to the Bahamas on the insistence of Sir Hans Sloane, who sponsored him in return for specimens for his cabinet - eventually to become the British Museum. Because of this Bahaman trip, Catesby's pioneering work "The Natural History of Carolina, Florida and the Bahama Islands" (1731-1743) contains paintings and descriptions of numerous marine animals pertinent to our Caribbean area. Among the 220 plates in the "Natural History " are the first colored figures of many species of fishes, crustaceans, and gorgonian corals which are wide spread in the West Indian Islands. Cateby's West Indian fishes have been identified in Linnean nomenclature by Goode (1876) and Jordan (1884). Among the best illustrations of the 44 species represented are those of the Squirrel fish (Holocentrus ascensionis (Osbeck)), which Catesby called "Perca marine rubra;" the Lane Snapper (Lutjanus synagris (Linn.)) or Salpa purpurascens variegata"; the Coney (Cephalopholis fulvus (Linn.)) or "Turdus cauda convexa;" and the Cottonwick (Haemulon melanurum (Linn.)) or "Perca marine cauda nigra." Catesby was careful to record the vernacular names of fishes used by the Bahaman fishermen, and these provide additional clues to exact identifications today as many of them are still current among fishermen in the Florida Keys and the Bahamas. Many distinguished names are listed among the 156 subscribers to his "Natural History," and the book went through three editions. Catesby gained a reputation as England's "elder statesman" of American natural history, and those who wanted to know more about America sought his advice - among them Linnaeus' student Kalm, who recorded an impression of an honest, unaffected and modest gentleman. In spite of a considerable measure of fame, after his death in 1749 Catesby was soon forgotten in the growing turmoil that England was experiencing with her colonies - and, besides, his name was an unpopular one because one of his forbears, Robert Catesby, was the instigator of the infamous Gunpowder Plot.

Many observations about wind, weather, currents and other factors important in navigation began to accumulate and these represent early contributions more directly pertinent to oceanography proper. Romans (1779 and later dates) prepared a set of sailing directions for the Straits of Florida and passages in the Bahamas and West Indies. Atkins (1735) described a number of the West Indian Islands and gave remarks on the winds, tides and currents of various places. He speculated upon the cause of the Current of Florida, described conditions preceding a hurricane, their causes and how they may be predicted, and gave a vivid first-hand account of the hurricane of August 28, 1722, at Port Royal which read in part: "The present Hurricane was a Week after our Arrival; began at eight in the morning, two Days before the Change of the Moon, gave at least 48 Hours notice, by a noisy breaking of the Waves upon the Kays ... and the two Nights preceding, prodigious Lightnings and Thunder; ... I was ashore at Port-Royal, and found all the Pilots returned from the Windward part of the Island ... and observing upon the unusual Intumescence of the Water, so great the Day before, and beat so high that our Boats could not possibly put on shore at Gun Kay to take the Men off that were set there ... Betimes next Morning, the Wind began in Flurrys at N E and flew quickly round to S E and S S E where it continued the Stress of the Storm, bringing such Quantities of Water, that our little Island was overflowed 4 foot at least; so that what with the fierce driving of Shingles ... about our Ears, and Lumber about the Streets, those without doors were every Moment in danger of being knocked on the Head, or carried away by the Stream. Within it was worse, for the Waters sapping the Foundations, gave continual and just Apprehensions of the Houses falling, as in effect half of them did, and buried their Inhabitants: nor indeed after the Storm had began, was it safe to open a door, especially such as faced the Wind, lest it should carry the Roofs off; and escaping thence, there was no place of Retreat, we remaining in a very melancholly Situation both from Wind and from Water. The perils of false Brethren was nothing to it."

4. A CENTURY OF SCIENTIFIC EXPLORATION (1850-1950)

The latter part of the 18th Century and the first half of the 19th were not marked by spectacular advances in knowledge of the Caribbean area, and form a century of transition between an era of initial exploration and one of scientific inquiry. At the beginning of this transitional period, Linnaeus (1758) perfected his system of binominal nomenclature which provided the mechanism for vast strides in cataloguing, describing and studying the living world; and towards its end, Darwin advanced his theory of Natural Selection - two of the most significant achievements in science.

Individual collectors and naturalists continued to obtain and describe marine novelties from the Caribbean, and the systematics of most animal groups advanced significantly in many publications made possible by Linnaeus' system of naming. Esper's work on "zoophytes" (1788-1830), Ellis and Solander's

Natural History of Zoophytes (1786), Lamarck's Histoire Naturelle des Animaux sans Vertèbres (1816), Cuvier's Le Règne Animal (1817), H. Milne Edwards' Histoire de Coralliaires (1875-60) and many other works advanced the knowledge of marine animals in the Caribbean and throughout the world.

If scientific progress in the 19th Century got off to a slow start, it soon caught up because this was the century that saw the beginning of marine science, in the Caribbean as well as around the world.

The incomparable expedition of H.M.S. "Challenger" (1872-1876) is sometimes cited as the beginning of the oceanographic history of the Caribbean Sea. Whereas the "Challenger" pioneered by occupying eight stations in the Caribbean, it really did not make any substantial inroads on the "oceanographic vacuum" in this area. The Caribbean with its total area of 2,640,000 square kilometers, contains five basins with depths from over 3000 to more than 6000 metres. Even though occasional specimens had been collected from traps and fishing lines set in considerable depths- as deep as 200 metres, to judge by the species reported - virtually nothing was known of the bottom and its inhabitants beyond the littoral zone until the work of the U.S. Coast Survey steamer "Blake". That vessel, under the command of Lt. Cdr. C.D. Sigsbee in 1877 and 1878, and Lt. Cdr. J. R. Bartlett in 1879, conducted the first significant observations on the oceanography and marine biology of the Caribbean Sea during three historic cruises. During these voyages, many data concerning the currents, still regarded as excellent even by modern standards, were collected along with information about the bottom sediments and water temperatures. Also a part of these cruises was a dredgingprogram under the direction of Alexander Agassiz, which occupied more than 300 stations in the Caribbean over a cumulative period of six months in 1879 and 1880, and about 100 more in the Gulf of Mexico, Straits of Florida, and Bahamas in 1877, 1878, and a short time in 1880. Considering the rough bottoms prevailing over much of the area explored, this was a major accomplishment in itself as we can say from first-hand experience on our own cruises, and it resulted in the first comprehensive view of the Caribbean marine fauna at sub-littoral depths. Papers describing the spectacular collections obtained were published in the Bulletins and Memoirs of the Museum of Comparative Zoology, where we find contributions by some of the foremost scientists of that day - A. Agassiz, R. Bergh, P.H. Carpenter, W.H. Dall, E. Ehlers, G. Brown Goode and T.H. Bean, L. von Graff, Th. Lyman, A. Milne-Edwards and E.L. Bouvier, L.F. de Pourtalès, A.E. Verrill and many more. The pioneering contributions by these specialists form the basis for our knowledge of the Caribbean deep-water fauna and many of them have not been surpassed up to the present time. The general results of these cruises were admirably summarized by Alexander Agassiz (1888) in his Three Cruises of the U.S. Coast and Geodetic Survey Steamer Blake, which remains a source of valuable information to this day.

If we use our broader view of the limits of the Caribbean area, then we must take into account some oceanographic explorations even earlier than those of the "Blake".

The Congress of the United States established the U.S. Coast Survey in 1807. This bureau, in the process of carrying out its mission of exploring and charting the coasts of the United States, accomplished some of the earliest scientific explorations in our area of interest. Of particular concern was the exploration of the Gulf Stream, which began in 1844. A series of deep-sea investigations of physical problems of the Gulf Stream was undertaken by A.D. Bache in 1846 and expanded in subsequent years under Benjamin Peirce, Carlile Patterson, and Julius E. Hilgard.

The first systematic deep-sea explorations in the Straits of Florida were undertaken in 1867 and 1868 by Count L.F. de Pourtalès on the Coast Survey steamers "Corwin" and "Bibb". These explorations extended downward to more than 1500 metres in the channel between Florida and Cuba, and revealed a remarkable fauna inhabiting considerable depths. Many new kinds of invertebrates brought to light by these dredgings gave rise to speculations about a relationship of the deep-water fauna with those of past geological ages,and even though such theories may not have been borne out precisely, these early investigations emphasized the great scientific value of studying the bottom fauna of the Straits of Florida.

In 1872, Dr. William Stimpson aboard the "Bibb" conducted a series of dredge hauls, several of them deeper than 1000 fathoms, in the Yucatan Channel in connection with a survey for a proposed telegraph cable, and in the vicinity of the Tortugas and Marquesas Keys. Immediately thereafter, Dr. Stimpson joined the U.S.S. "Bache" for dredging off the west coast of Florida andlater in the southwestern Straits of Florida off the Tortugas.

On the voyage of the "Hassler" from Boston to San Francisco in 1871-72, eight dredge stations were made by Count L.F. de Pourtalès under the direction of Prof. Louis Agassiz off Barbados, and 26 others along the Atlantic coast of South America.

Science is indebted to another U.S. Government vessel, the U.S. Fish Commission steamer "Albatross", for a wealth of information in the field of fisheries, marine biology, hydrography, and bathymetry, obtained in the western Atlantic, the tropical eastern Pacific, the North Pacific, and the Far East. A substantial body of this information was collected in the Caribbean, the Gulf of Mexico and along the east coast of South America. Because this great ship is now all but forgotten, let me recount some of the memorable facts about her.

Built in Wilmington, Delaware, in 1882, to fill the need for an ocean-going research vessel which had been demonstrated by the investigations of the newly established U.S. Commission of Fish and Fisheries between 1871 and 1880, the steamer "Albatross" was the first vessel specially designed and built for marine research by any government. Her career of 39 years of distinguished service began in the infancy of oceanography when the chief goal of deep-sea expeditions was to survey the faunas of the deep oceans, and extended into the modern period of collecting accurate physical and chemical oceanographic data. Although the four-year cruise of H.M.S. "Challenger" marked the birth of scientific oceanography, the immense volume of work accomplished by the "Albatross" has earned for her, too, a place of honor in the history of ocean science.

So that you can appreciate how oceanographic field work was done 85 years ago, I will tell you a little about the ship herself. She had a beam of 27'6", a length of 200 feet at the 12-foot water line and displaced 1074 tons, with a net registered tonnage of 384. Constructed of iron, the "Albatross" was brigantine rigged and carried 7521 square feet of sail (Fig. 2). Being designed for deep-sea dredging, the ship was furnished with two engines to handle the dredging cable. The hauling engine (Fig. 3) was a 15-1/2 horsepower steam engine located on deck forward of the main mast. A separate reeling engine operated the storage drum below deck (Figs. 4, 5) which had a capacity of about 8000 metres of 3/8 inch wire rope. To absorb sudden strains, a dredging cable was rigged with rubber accumulators of the type previously used aboard the "Blake" and initially on the "Challenger". The ship had twin screws and her rudder and steering mechanism were much larger than usual, in order to provide manoeuvrability while on station. She also was equipped with Sigsbee's sounding machine (Fig. 6), used earlier aboard the "Blake".

The "Albatross" had two laboratories, one 14 feet long in the deck house (Fig. 7) and the other 20 feet long on the berth deck below. The lower laboratory (Fig. 8) contained photographic dark room, chemical lab, and specimen storage. Space for nets, alcohol, and various other equipment was provided in the hold below. Those who have gone to sea in present-day oceanographic ships will be interested in the outfitting of the Captain's cabin (Fig. 9) and the ward room which was similarly furnished. In these views of the interior, you will see that there are electrical fixtures throughout - the "Albatross" was the first U.S. Government ship completely equipped with electric lighting - but with oil-lamps as a back-up in case the new-fangled 51-volt generator should fail. While we are speaking of "records", I might mention also that on November 27, 1899, the "Albatross" made the deepest successful dredge haul up to that time, from a depth of 7632 metres (4173 fathoms; 21°18'S, 173°31'W, station 3693).

The scientific results of the work of the "Albatross" are now far too numerous to compile. In 1901 when C.H. Townsend compiled a bibliography, there already were 233 titles. Certainly by now they would fill much more than the fifty volumes of "Challenger" results, but then, the "Albatross" worked for a longer period. The results of cruises directed by Alexander Agassiz were published chiefly by the Museum of Comparative Zoology in its Bulletin and Memoir series, and many papers from other cruises appear also in the publications of the Smithsonian Institution and the U.S. Bureau of Fisheries.

Of particular interest to us today are the cruises of the "Albatross" to the Caribbean in 1884 to do hydrographic work and soundings for the U.S. Navy; through the Straits of Florida and the Gulf of Mexico in 1885 to investigate the snapper banks and other fishery resources of the Gulf; through the Bahamas in 1886 for hydrographic and fisheries investigations; along the coast of South America in 1887-1888, while en route to California; and finally, in 1919, to Cuba, Yucatan and the Gulf of Mexico. The "Resident Naturalist" on the cruises of 1884-1888 was J.E. Benedict, whose research dealt with decapod Crustacea; the cruise in 1919 was directed by W.W. Welch of the U.S. Bureau of Fisheries. During these cruises, the "Albatross" occupied 189 dredging and 806 hydrographic stations in the Caribbean and adjacent waters, adding materially to the foundation of knowledge established by the "Blake".

Soon after Puerto Rico became a part of the United States, the Commissioner of Fish and Fisheries decided to make an investigation of the waters in and around the island with reference to their fauna and fisheries resources. Accordingly, in December 1898, the U.S. Fish Commission steamer "Fish Hawk" with a corps of specialists under the direction of Barton Warren Evermann was sent to Puerto Rico for that purpose, where it remained until the latter part of February 1899. Large collections of aquatic animals were made, thereby greatly extending the knowledge of the fauna of the island and of the West Indies in general, and special consideration was given to the economic fisheries.

Fig. 2 U.S. Fish Commission Steamer "Albatross." Photo courtesy of the Smithsonian Institution.

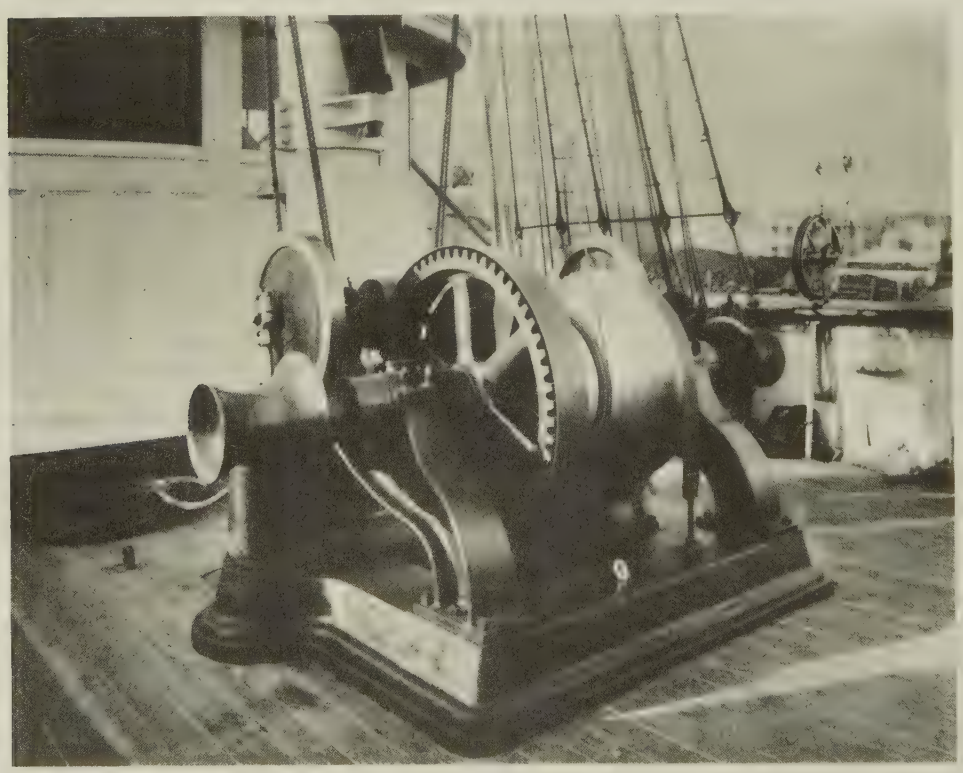

Fig. 3 U.S. Fish Commission Steamer "Albatross". Hauling engine. Photo courtesy of the Smithsonian Institution.

Fig. 4 U.S. Fish Commission Steamer "Albatross." View looking aft on berth deck showing position of storage drum for trawl cable. Photo courtesy of the Smithsonian Institution.

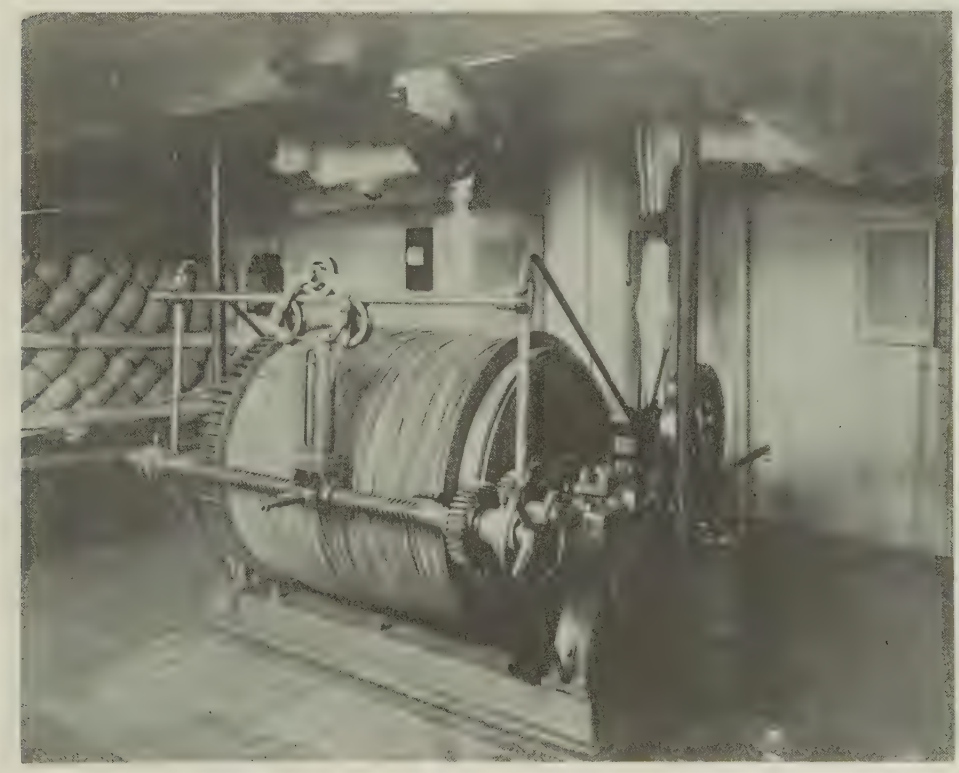

Fig. 5 U.S. Fish Commission Steamer "Albatross." Reeling engine and storage drum. Photo courtesy of the Smithsonian Institution.

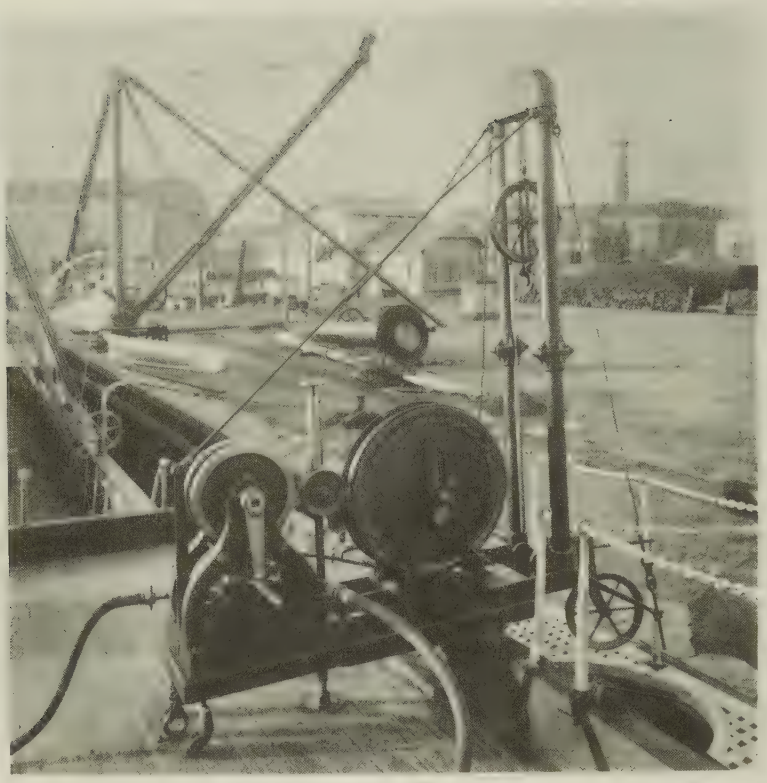

Fig. 6 U.S. Fish Commission Steamer "Albatross." Sigsbee's sounding machine. Photo courtesy of the Smithsonian Institution.

Fig. 7 U.S. Fish Commission Steamer "Albatross." Upper laboratory. Photo courtesy of the Smithsonian Institution.

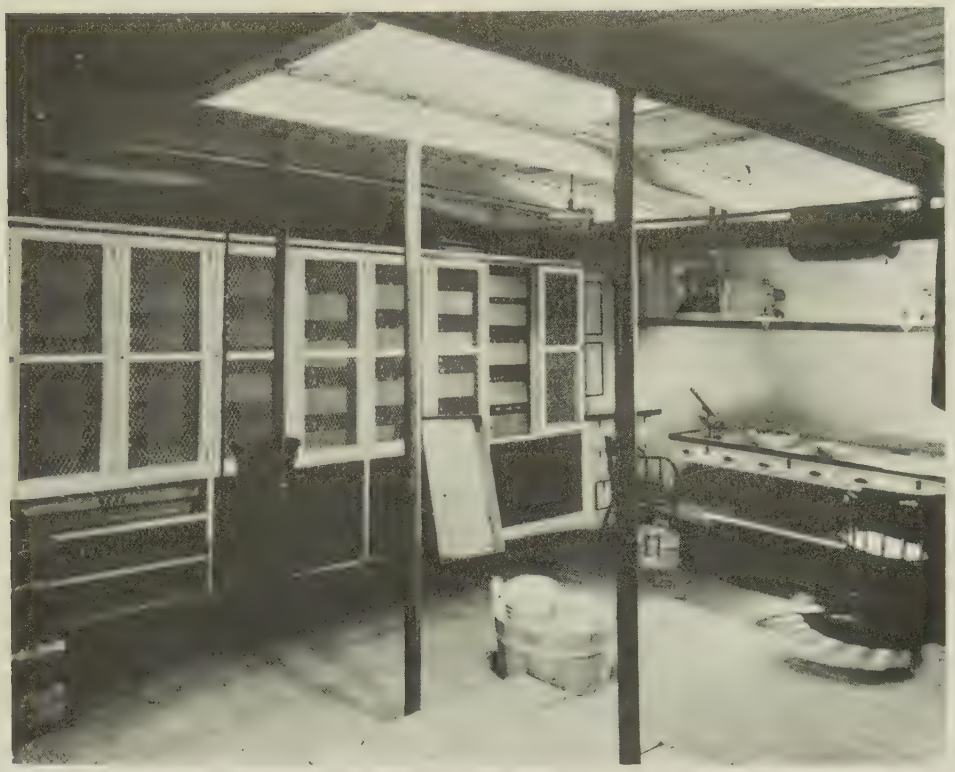

Fig. 8 U.S. Fish Commission Steamer "Albatross." Lower laboratory. Photo courtesy of the Smithsonian Institution.

Fig. 9 U.S. Fish Commission Steamer "Albatross." Interior of poop cabin, looking aft. Photo courtesy of the Smithsonian Institution.

The "Fish Hawk" (Fig. 10) was built by the U.S. Commission of Fish and Fisheries in 1880 for the purpose of surveying fishing grounds and assisting in fish-catching operations. In 1895 and 1896, the "Fish Hawk" surveyed the oyster grounds in the Gulf of Mexico off northwest Florida. In 1898, she undertook hydrographic exploration in Gulf coastal waters off Alabama. After the Puerto Rico cruise, the "Fish Hawk" investigated the sponge grounds in the Gulf of Mexico off West Florida, exploring the grounds from Apalachee Bay to Key West in 1901 and 1902. In 1905, 1911 and 1913, the "Fish Hawk" surveyed oyster grounds and made hydrographic investigations along the Texas Coast.

The results of the expedition to Puerto Rico were published in 20 special reports occuping nearly 1000 pages in volume 20 of the Bulletin of the U.S. Fish Commission. These included a major report upon the fishes by Evermann and Marsh, Fisheries and Fish trade by W.A. Wilcox, and special papers on various invertebrate groups by prominent experts of that time.

During the months of February through April 1925, Mr. Harry Payne Bingham, aboard his yacht "Pawnee", conducted an expedition from southern Florida through the Bahamas, Cuba, Isle of Pines and Grand Cayman westward to Swan Island and the coast of British Honduras. The poorly known Misteriosa Bank and Glover Reef were localities of special interest to the expedition. Some of the results of this cruise, undertaken for Yale University, have been published in the Bulletin of the Bingham Oceanographic Collection of the Peabody Museum (Parr, 1927-1928).

In 1933, Mr. Eldridge R. Johnson of Philadelphia, Pennsylvania, sponsored an expedition to the Puerto Rico Deep aboard his yacht "Caroline," under the scientific direction of Dr. Paul Bartsch of the Smithsonian Institution. The "Caroline" was a twin-screw diesel ship 279 feet in length with a beam of 38 feet, which permitted sea-going operation in virtually any weather. She was equipped with an echo sounder and other instruments for a full scale oceanographic expedition to gather data concerning physical and chemical as well as biological problems. Special reports upon many of the deep-sea organisms have been published by specialists in a special series of papers in the Smithsonian Miscellaneous Collections. Dr. Bartsch published popular accounts of the Johnson-Smithsonian Deep-sea Expedition (1933b, 1934) as well as a list of the stations occupied (1933a). A number of unusual and new organisms were obtained and considerable information about the distribution of the Caribbean deep-sea fauna was added to the basic knowledge already established by the "Blake" and the "Albatross".

In 1937 and 1938, Lord Moyne's Motor Yacht "Rosaura" made a number of biological collections in the Caribbean, in the vicinity of Grand Cayman, off British Honduras, Turneffe, Bonacca Island, Mosquito Banks, and Grenada. Stations then were made along the South American Coast to the northeastern part of Brazil, thence to Fernando Noronha. Reports on various marine animals have been published in scientific journals.

The R/V "Oregon" (Fig. 11) of the U.S. Fish and Wildlife Service was engaged almost continuously over the past 18 years in the exploration of existing and potential fishing grounds in the Gulf of Mexico and Caribbean area. Since her first station on May 23, 1950, the "Oregon" has occupied nearly 8000 stations, of which 1461 were in the Caribbean, 3914 in the Gulf of Mexico, 1860 off the Atlantic coast of Florida, and 394 off South America. Collections were obtained from a wide range of depths reaching as deep as 2000 fathoms, with a variety of gear chiefly of commercial design. Included were bottom trawls of various sizes and design, midwater trawls, tumbler dredges, plankton and nekton nets, gill nets, long lines, dip nets, and others.

The amount of biological material collected by R/V "Oregon" must, by now, far exceed that taken by any other exploratory vessel. Much of this material is housed at the Service's laboratory at Pascagoula, Mississippi, and a substantial segment of it at the U.S. National Museum. Smaller parts of the collections have gone to the laboratories or museums where collaborating scientists were affiliated, for example, the Chicago Natural History Museum, the University of Michigan and the University of Miami. Specialists in many fields have collaborated in the identification of specimens obtained by the "Oregon", and their research has been published in many scientific journals. The results have certainly advanced our knowledge of specific groups of organisms and of the Fauna of the Caribbean Sea and Gulf of Mexico, but the collections are so widely scattered and the results so diverse that it is unlikely any coordinated analysis of the distribution, abundance and composition of the bottom fauna can ever result. The mere task of keeping track of published work will be many times more difficult than it was - and is -in the case of that dealing with the "Albatross" collections.

The U.S. Fish and Wildlife Service has also conducted biological surveys from two other vessels in the Gulf of Mexico and Caribbean areas in the past decade, the M/V "Silver Bay" and the M/V "Combat". The "Silver Bay" has occupied 433 stations in the Caribbean Sea and 1425 in the Gulf of Mexico; the "Combat" about 80 stations in the Caribbean. More recently, the vessels "Geronimo" and "Undaunted" of the Tropical Atlantic Biological Laboratory, Bureau of Commercial Fisheries, together have spent a total of over a year in the Caribbean and adjacent waters carrying out fishery-oceanographic surveys in

Fig. 10 U.S. Fish Commission Steamer "Fish Hawk." Photo courtesy of the Smithsonian Institution.

Fig. 11 Motor vessel "Oregon," U.S. Fish and Wildlife Service.

regard to the distribution and ecology of tunas. Of this time, about nine months during 1965, 1966 and 1967 were devoted to operations in the Caribbean proper.

In 1964 and 1965, the Soviet Union in cooperation with the Republic of Cuba conducted oceanographic investigations in the Caribbean Sea and Gulf of Mexico from the research vessels "Akademik A. Kovalevskii" and "Mikhail Lomonosov". Biological as well as physical and chemical problems were studied and the results published under the editorship of V.A. Vodyanitskiy (1966). Included are reports upon hydrographic, hydrochemical, and geological investigations, water circulation in the Caribbean and Gulf of Mexico, phytoplankton and primary production, zooplankton, physiology and other biological subjects.

In giving so much attention to the work accomplished by complex expeditions, we should not lose sight of the contribution made by individual collectors and investigators. This tradition, carried on from the early days of exploration by Oviedo and later by Sloane, Catesby, Browne and others, has been continued into our own century and our own day by many indefatigable collectors with great success. Some of these concentrated upon one or a few animal groups, but others were omnivorous. Among the latter we can mention van der Horst at Curaçao in 1920, Kükenthal and Hartmeyer throughout the West Indies in 1907, and Wagenaar Hummelinck in many localities, chiefly Dutch, in 1930, 1936-37, 1948-49, who, with many collaborating specialists have contributed so much to our knowledge of the Caribbean in the 19th century.

5. PERIOD OF MODERN RESEARCH

With the exception of the kinds of practical observations that were made by ship's captains and navigators in unknown waters and which I have alluded to earlier, the physical, chemical and geological aspects of ocean science are relatively new studies. They did not begin seriously until the period I have called the Century of Scientific Exploration, and comparatively late in that. Measurements of various physical and chemical properties were made by the U.S. Coast Survey vessels already mentioned, and, in increasing numbers by the steamer "Albatross". Bottom samples were collected routinely by the "Blake" and "Albatross" for study of deep-sea sediments. Intensive investigation of the sediments and of underlying geological structures could not begin, however, until the necessary equipment was developed for making observations. Reliable echo-sounders, grab samplers, coring devices, and apparatus for seismic-reflection profiling are largely developments of the past 20 or 25 years, or even less, although some were developed in principle much earlier. Therefore, research employing these techniques has been undertaken only in very recent times. The vessels of the Woods Hole Oceanographic Institution, the Lamont Geophysical Observatory, and the Institute of Marine Sciences of the University of Miami are largely responsible for investigations employing this kind of instrumentation in the Caribbean.

Even though increasingly sophisticated instrumentation has been available for use upon vessels of steadily improving design and sea capabilities for nearly a century, it has been only within the last 20 years or less that such modern facilities have been used in a methodical, long-range manner or in synoptic and cooperative programs with a view toward synthesizing the broad results. Such comprehensive programs got under way in the Atlantic Ocean with the International Geophysical Year (1957-59) and the Equalant Expeditions of 1964-65.

As was already mentioned, the U.S. Coast Survey began an attack on the bathymetry and dynamics of the Gulf Stream about 100 years ago, and not long afterward the U.S. Commission of Fish and Fisheries commenced an intensive faunal survey of fisheries resources that moved from the Atlantic to the Pacific and even into the Far East. These and other programs have resulted in a large amount of valuable information in a widely scattered and uncohesive form. Knowledge of the tropical Atlantic, and especially the Caribbean was of a fragmentary nature and remains so to a very large extent.

The vessels of the Woods Hole Oceanographic Institution and the Lamont Geophysical Observatory have been making methodical observations of physical, chemical, geological and geophysical phenomena in recent years. Faunal investigations, although on a broad scale, have remained oriented toward purely descriptive goals, partly because of the many gaps in knowledge, partly because of the overwhelming task of handling large collections, studying them and analyzing the results.

In the very early days of the Institute of Marine Sciences at Miami, the need for a better knowledge of our local fauna was keenly felt. Even though several of the staff long ago made dredging stations off Miami from the Institute's small boats, lack of equipment made it impractical to conduct any coordinated investigation of the deepwater fauna.

By 1961, however, the Institute had grown to the point where it was operating vessels large enough

for dredging and trawling, it had personnel with interest extending beyond the shallows, and the time seemed ripe for undertaking the deepwater work that so many of us had so long wanted to do.

Offshore biological work requires a sea-going vessel with capabilities for both midwater and bottom trawling. For our investigations in the Straits of Florida, we have used almost exclusively our R/V "Gerda" (Fig. 12), a Danish-built vessel designed along the lines of a North Sea trawler type.

The program originally was designed to provide a broad, general view of the offshore fauna of the Straits and its geographical and ecological distribution. Such an objective requires (1) sampling the whole water column over the entire area, covering all depths and types of bottom; and (2) samples of sufficient size to assure obtaining a reasonably complete representation of the fauna and an indication of the relative abundance of species. Obviously, these requirements cannot be met in full because of the limitations imposed by time and equipment.

In order to conduct a sampling program that would give us a reasonably reliable picture of the fauna of the Straits, we laid off the area from the Dry Tortugas to Jupiter Inlet on a 5-mile grid. Because of its accessibility, the area between Florida and the Bahamas has been covered very intensively, and we have obtained samples from almost every quadrat. In the regions more distant from home base, where running time becomes an important factor, the number of quadrats sampled is smaller. Eventually, however, we hope to obtain collections from virtually every square in the Straits. Since this survey began, "Gerda" has occupied over 1000 stations, chiefly in the Straits of Florida and its approaches, and in the northwestern Caribbean.

In 1964, the faunal survey of the Straits of Florida was expanded into a full-scale, deep-sea biology program by conducting operations also from the Institute's 176-foot R/V "John Elliott Pillsbury" (Fig. 13). The facilities of this vessel permit the use of larger gear, such as the 10-foot Isaacs-Kidd midwater trawl and the 40-foot otter trawl, in addition to the types previously used abord the "Gerda". In the late summer of 1964, a cruise was made to Bermuda, and in the summer of 1966 the first of a projected series of expeditions to the Caribbean was undertaken. In 1967 and 1968, three further cruises have been made in the Caribbean and off the Guianas, resulting in over 650 stations.

Extensive hydrographic, geological and geophysical work has been done from R/V "Pillsbury", a substantial part of it in the Caribbean area. During coring operations in 1963, the Institute of Marine Sciences collected eight long, undisturbed piston cores of globigerina ooze from the deepest parts of the Caribbean Sea and obtained the longest stratigraphic section of this sediment obtainable with piston-coring techniques. Cooperative efforts by the Institute of Marine Sciences, Woods Hole, Lamont Geophysical Observatory, and the Scripps Institution are directed toward obtaining longer stratigraphic sections of deep-sea sediments. In December 1963, scientists of the Institute were the first to successfully employ deep sea drilling to obtain cores from a depth of 600 metres on the Nicaragua rise south of Jamaica. This technique greatly extended the length of cores obtainable. In 1964, improved techniques of coring were employed from R/V "Pillsbury" in the Venezuelan Basin to obtain over 600 feet of sediments, including a core of over 71 feet. Numerous methods are used in the analysis of such samples, including mass spectrometry to investigate temperature at the time of deposition.

Seismic profiling in the Caribbean has been undertaken by geomorphologists of the Institute of Marine Sciences aboard R/V "Pillsbury". Many profiles between Saba, Martinique and Dominica were made during 1963 and 1964, permitting the recognition of several geological units and an interpretation of their relationships.

A description of all the Institute's activities in the Caribbean would be both impossible and out of place in the present review. Summaries of all operations can be found in the Annual Reports of the Institute.

At the present time, a number of research centres are scattered over the whole of the Caribbean and adjacent areas. In Chapter 1 of his invaluable compendium on the Gulf of Mexico, Galtsoff (1954:30-32) reviewed the research laboratories then operating around the periphery of the Gulf. That information will not be repeated here, but subsequent changes should be mentioned briefly. The Marine Laboratory (now the Institute of Marine Sciences) of the University of Miami no longer operates a base at Apalachicola, but has expanded considerably at its new location on Virginia Key in Biscayne Bay. It has been joined on that island by the Tropical Atlantic Biological Laboratory of the Bureau of Commercial Fisheries and the oceanographic laboratory of the Environmental Science Service Administration (Department of Commerce), now in planning stages, to form a major marine science complex.

Fig. 12 Research vessel "Gerda," University of Miami. Photo by John W. Thompson.

Fig. 13 Research vessel "John Elliott Pillsbury," University of Miami. Photo by Donald J. Heuer.

In 1955 the American Museum of Natural History established a small marine station known as the Cape Haze Marine Laboratory near Placida on the Gulf coast of Florida. The laboratory moved to Siesta Kay, Sarasota, in 1961 and subsequently was renamed the Mote Marine Laboratory.

The Florida State Board of Conservation now operates a laboratory at Bayboro Harbor, St. Petersburg, from which many valuable investigations of the adjacent Gulf are conducted. University-associated laboratories are now located at Tampa (University of South Florida), Cedar Key (University of Florida), and Alligator Harbor (Florida State University).

A number of laboratories in Latin America and the Caribbean, not pertinent to Galtsoff's discussion but of interest to us here, should be mentioned. On the western shore of the Gulf of Mexico, for example, are the Estación de Biología Marina, Instituto Tecnológico de Veracruz, Mexico; Estación de Biología Pesquera de Campeche, Mexico; and, in the Caribbean, Estación de Biología Pesquera de Isla Mujeres, Quintana Roo, Mexico. In Costa Rica, the Tropical Science Center at San José is operated jointly by several universities through an agency known as the Organization of Tropical Studies. No permanent marine facility has yet been established in connection with that laboratory.

For many years the Smithsonian Institution has maintained a tropical research laboratory on Barro Colorado Island in Gatun Lake, Panama Canal Zone. That installation, now known as the Smithsonian Tropical Research Institute, has expanded to include laboratory facilities for marine research on both Caribbean and Pacific coasts of the Isthmus of Panama.

In Colombia, the Instituto Colombo-Alemán de Investigaciones Científicas commenced operation at Sta. Marta in 1966 under the joint auspices of the University of Giessen and the Universidad de los Andes in Bogota, to serve as a cooperative research centre for Colombian and German students and investigators.

The Estación de Investigaciones Marinas de Margarita, the Ford Foundation Science Project of the Universidad de Oriente (Cerro Colorado, Cumaná), the Instituto Oceanográfico of the Universidad de Oriente, Cumaná, the Centro de Investigaciones Pesqueras (Cumaná), the Fisheries Research and Development Project FAO (Maracaibo), and the Fundación Científica Los Roques are some of the research centres and organizations now active along the Caribbean coast of Venezuela. Off the Venezuelan coast on the Dutch island of Curaçao is located the Caribbean Marine Biological Institute, the source of much valuable information about the Caribbean.

On the island of Trinidad, the N.Y. Zoological Society maintains a laboratory for tropical research, chiefly terrestrial, at Simla; the McGill University operates the Bellairs Research Institute at St. James, Barbados; Fairleigh-Dickinson University (Rutherford, N.J.) has established a marine laboratory not yet in operation, near Christiansted, St. Croix, U.S.B.I.; the Institute of Marine Biology, University of Puerto Rico, has a marine station at Mayagüez; the Universidad Autónoma de Santo Domingo, República Dominicana, contains an Instituto de Biología Marina; the University of the West Indies at Mona, Kingston (Jamaica) has a small research laboratory at Port Royal on the south coast and, jointly with the University of New York (Stonybrook), a field facility on the north coast of the island.

We have little information as to the research laboratories now operating in Cuba, but certainly the following are active: Centro de Investigaciones Pesqueras (Bauta, Habana); and Instituto de Oceanología, Academia de Ciencias de Cuba, La Habana.

Finally, in the Bahamas, the Lerner Marine Laboratory of the American Museum of Natural History (New York) continues in operation at Bimini.

An admittedly incomplete tabulation of the work done by various vessels in the Caribbean area shows that in the past 100 years, about 10,000 biological stations alone have been occupied. Of these, 3446 were in the limits of the Caribbean proper. A rough plot of the cruise tracks of major expeditions, grouped according to purpose, time, and sponsorship shows some interesting results.

Prior to 1900, there were few investigations of the Caribbean sponsored by private institutions or foreign governments. Figure 14 shows the routes of the British "Challenger" Expedition, the cruise of the French "Chazalie", and the University of Iowa Bahama Expedition directed by Prof. C.C. Nutting (Nutting, 1895). U.S. Government activities during a similar period (Fig. 15) were widespread but not intensive, and operations in the Caribbean proper were chiefly those of the "Blake and the "Albatross".

Investigations by private organizations and foreign governments increased noticeably after 1900, as shown in Figure 16. The scope of U.S. Government field work during the same time is indicated in

Fig. 14 Biological Investigations. Cruise tracks of foreign and private expeditions, 1873-1896.

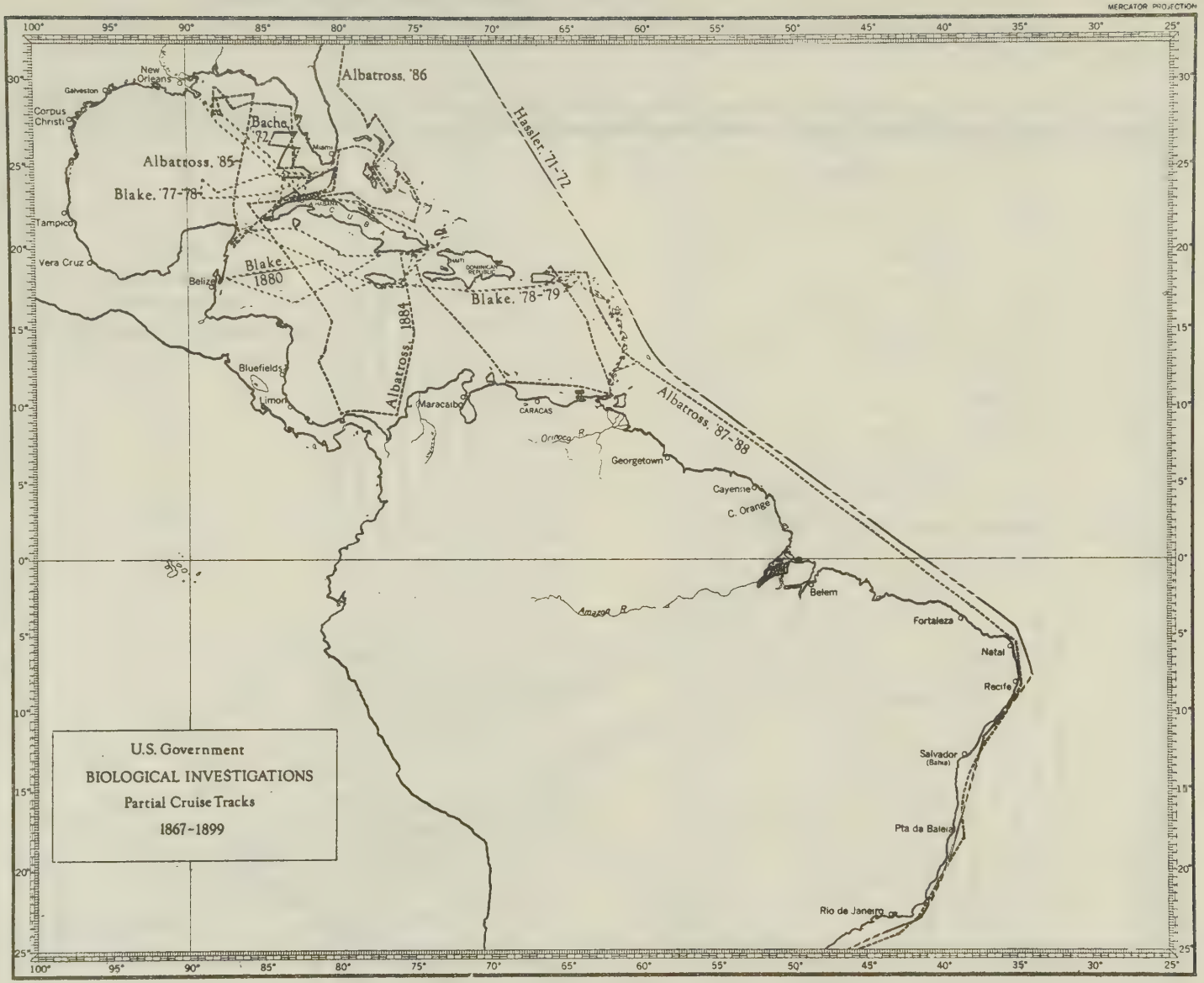

Fig. 15 Biological Investigations. Cruise tracks of selected U.S. Government expeditions, 1867-1899.

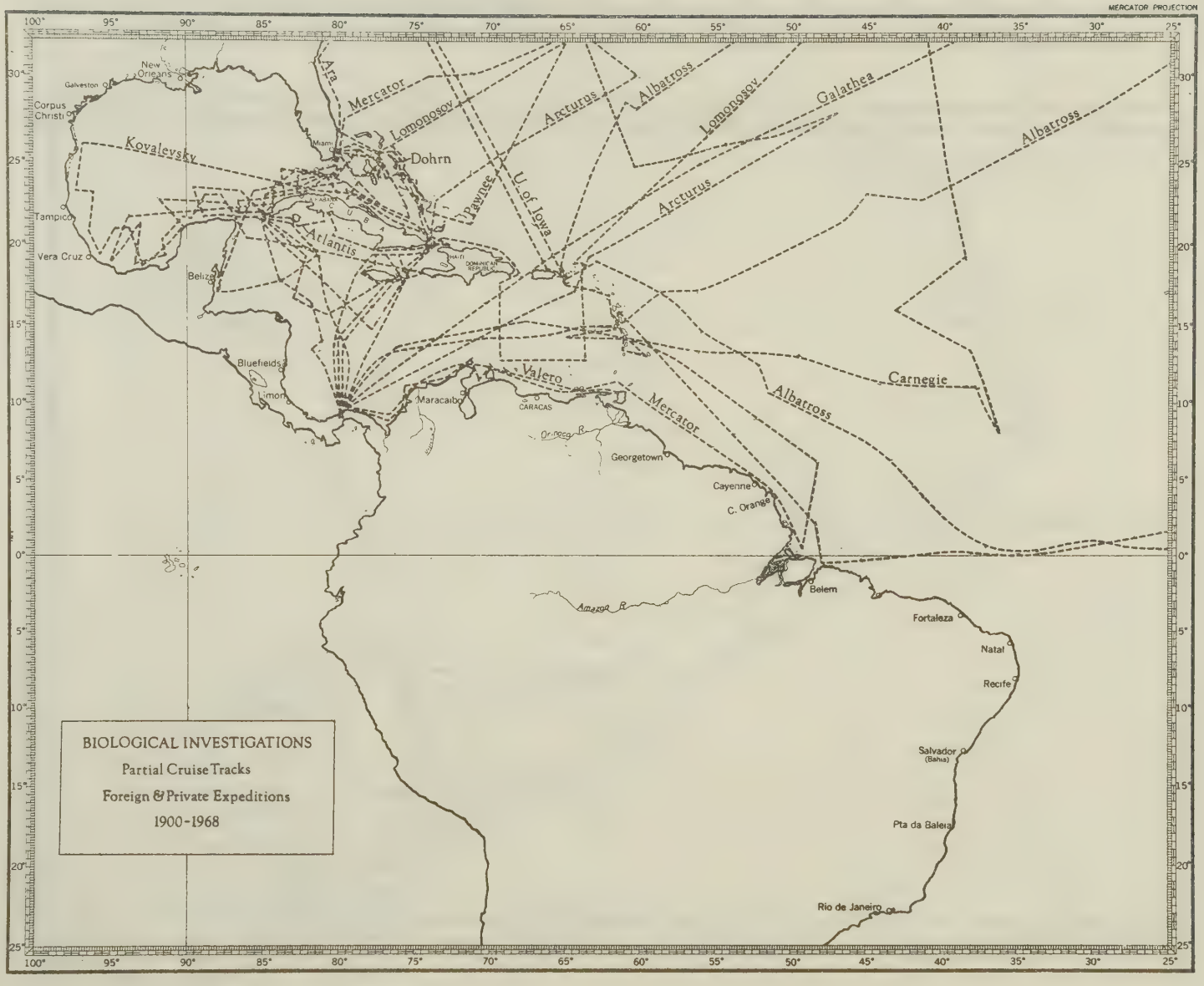

Fig. 16 Biological Investigations. Partial cruise tracks of foreign and private expeditions since 1900.

Figure 17, which is considerably abridged in the interests of clarity. Except for the Johnson-Smithsonian Deep-Sea Expedition abord the "Caroline", most of these cruise tracks mark the work of R/V "Oregon".

Some of the geological investigations by private organizations before 1960 are shown on Figure 18.

The areas investigated by the Institute of Marine Science from 1961 to 1968 under its macro-biology program, aboard both "Gerda" and "Pillsbury", are shown in abridged form on Figure 19. Excluded from this plot are the tracks of plankton investigations, which will be dealt with in another paper.

The tracks of hydrographic cruises by the Institute's vessels shown on Figure 20 are limited to the years 1961-1968. The inclusion of many cruises prior to this period would have greatly overcrowded the chart. Finally, the cruise tracks of geological investigations 1961-1968 are shown on Figure 21.

From all of this compilation and tabulation it is clear that an enormous amount of work has been done in the Caribbean and nearby waters since the development of modern research methods. It is tempting to draw the conclusion that scientific investigations in the Caribbean Sea have reached such a high degree of completion that we can relax and turn to other areas. But let me now emphasize that, in spite of more than a century of scientifically sophisticated investigations, preceded by two centuries of descriptive endeavour upon the marine flora, fauna and environment, the Caribbean is still inadequately known from almost every point of view. In regard to the marine animals and plants, it is no easy matter to obtain an accurate identification of any but the commonest species of the better-known phyla. Even in an area as intensively studied as south Florida, we still have no identification manuals of the common marine animals, and we rely heavily upon the incomplete and largely outdated series of handbooks begun by the New York Academy of Sciences under the title "Scientific Survey of Porto Rico and the Virgin Islands". Our own projected series of identification manuals, initiated in 1967 with the "Copepods of the Florida Current" (Owre and Foyo, 1967) is progressing slowly because it is fashionable to neglect the fundamentals in favour of more advanced and sophisticated research methods.

Surely, the knowledge of the hydrography and water circulation in the Caribbean is only now beginning to take shape, whereas the study of the geological structure of the Caribbean basin is still in its infancy. Therefore, let me urge that we not relax our investigations of any aspect of marine science in the Caribbean. The foundations still must be built in some fields and must be completed or strengthened in others.

6. ACKNOWLEDGEMENTS

In the preparation of this paper I have received the generous assistance of many people and have depended heavily upon the foundations laid by others. In particular, it is a pleasure to acknowledge the cooperation of the library and scientific staff of the Smithsonian Institution, especially Drs. Raymond B. Manning, Marian H. Pettibone, H.B. Roberts, and W.L. Schmitt; my associates at the Institute of Marine Sciences of the University of Miami, especially Mr. Dennis Opresko and Mr. Don Heuer; and Dr. L.B. Holthuis of the Rijksmuseum van Natuurlijke Historie at Leiden, with whom many conversations have provided a deeper insight into the more personal and human aspects of exploration and research in the Caribbean, and whose History of Carcinology of Surinam has been most helpful in the present connection. The photographs of the steamers "Albatross" and "Fish Hawk" were kindly made available by the Smithsonian Institution, and the Cantino Map by Dr. Eugenia Montanaro Gallitelli of the University of Modena, Italy. To all of these, and more, I am happy to express my thanks.

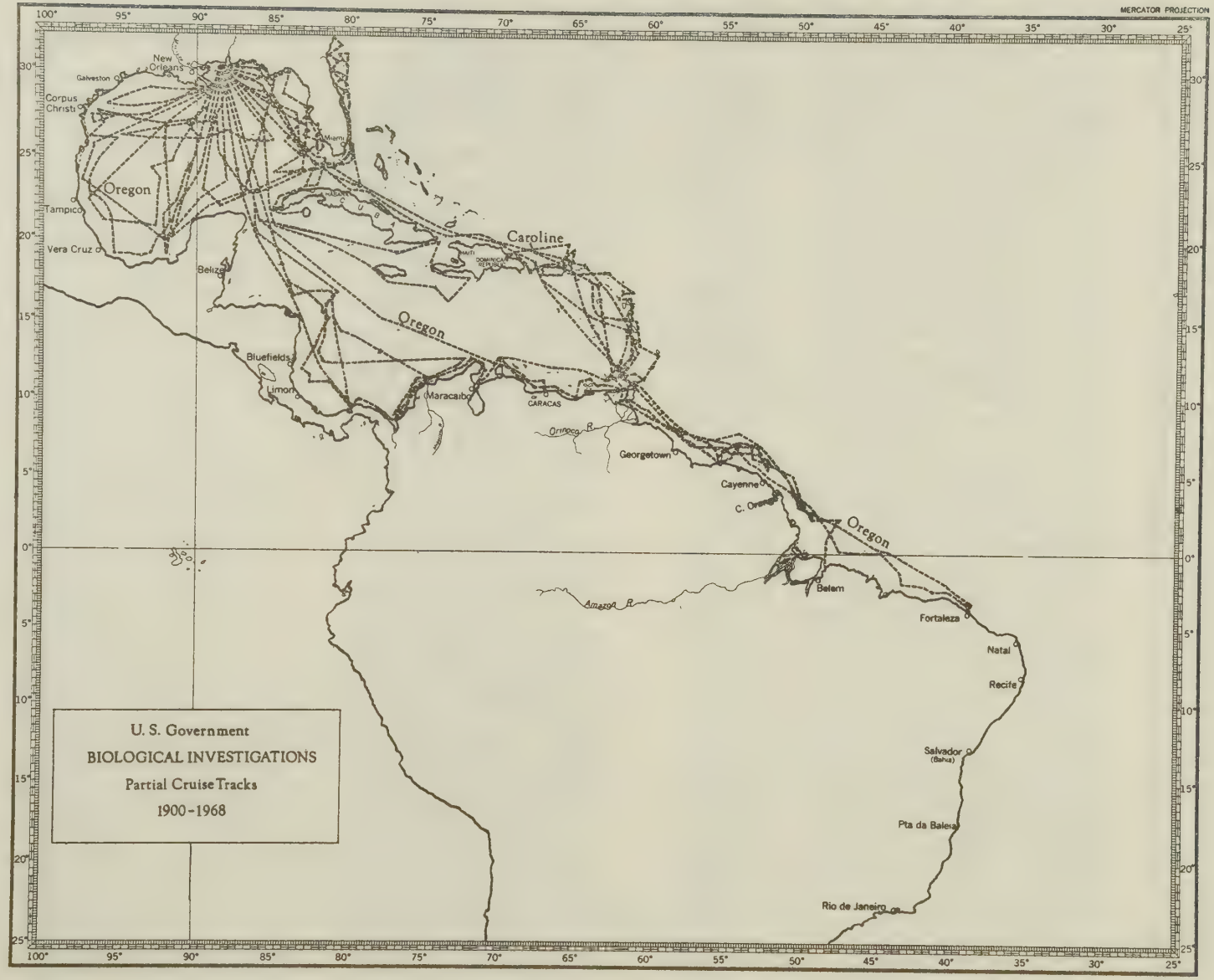

Fig. 17 Biological Investigations. Cruise tracks (simplified) of U.S. Government expeditions since 1900.

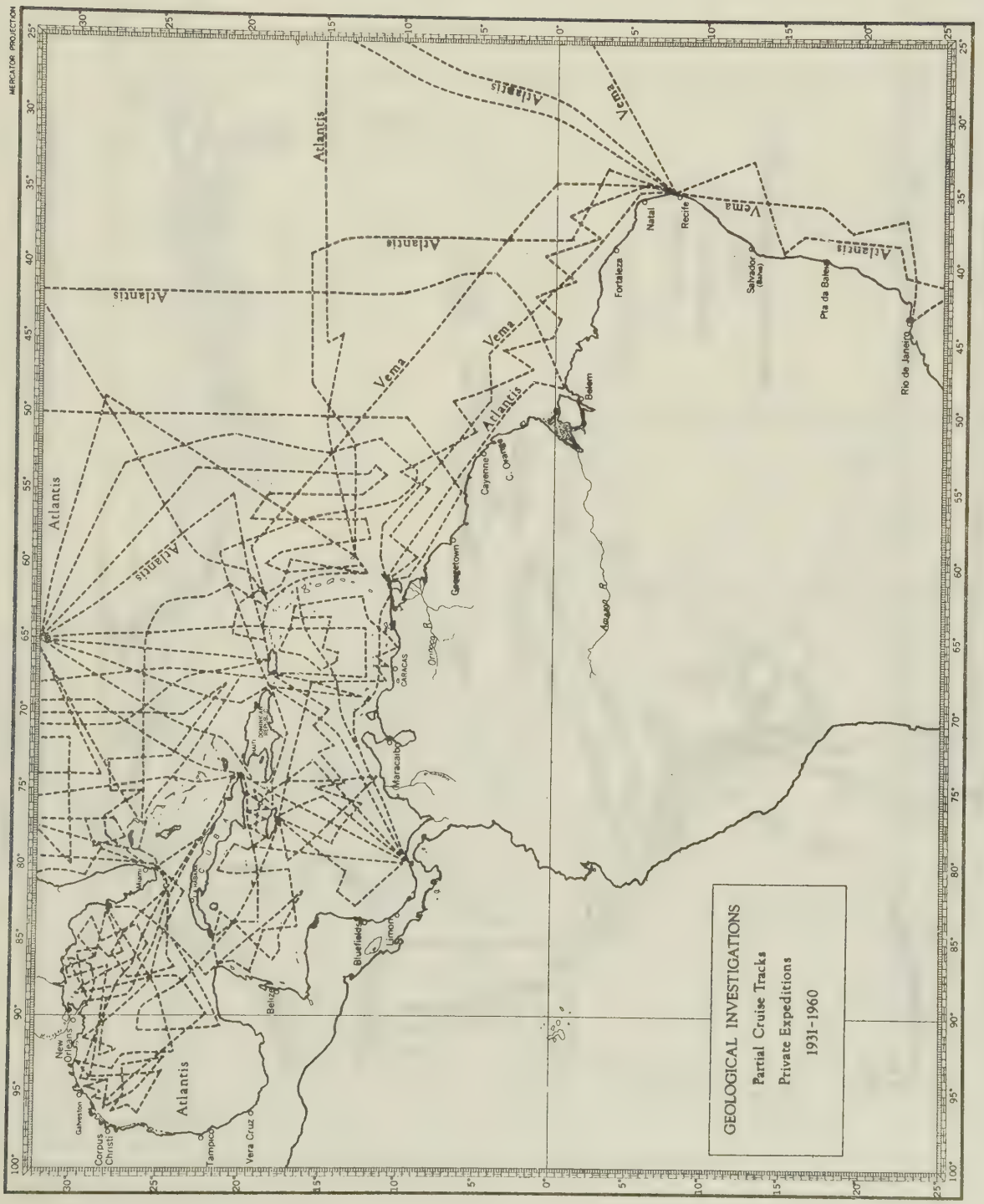

Fig. 18 Geological Investigations. Partial cruise tracks, private expeditions 1931-1960.

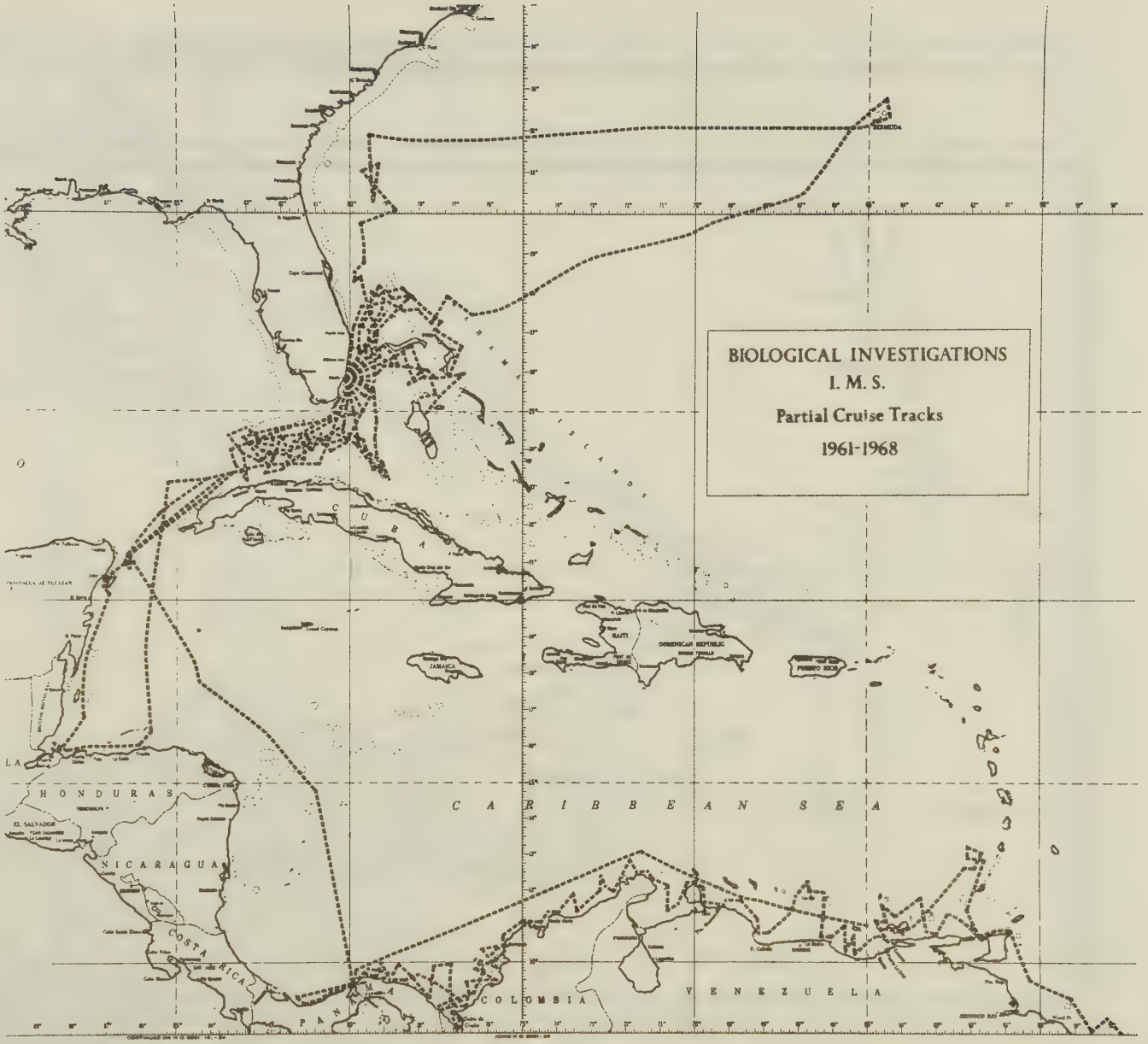

Fig. 19 Biological Investigations (excepting plankton). Partial cruise tracks, Institute of Marine Sciences, 1961-1968.

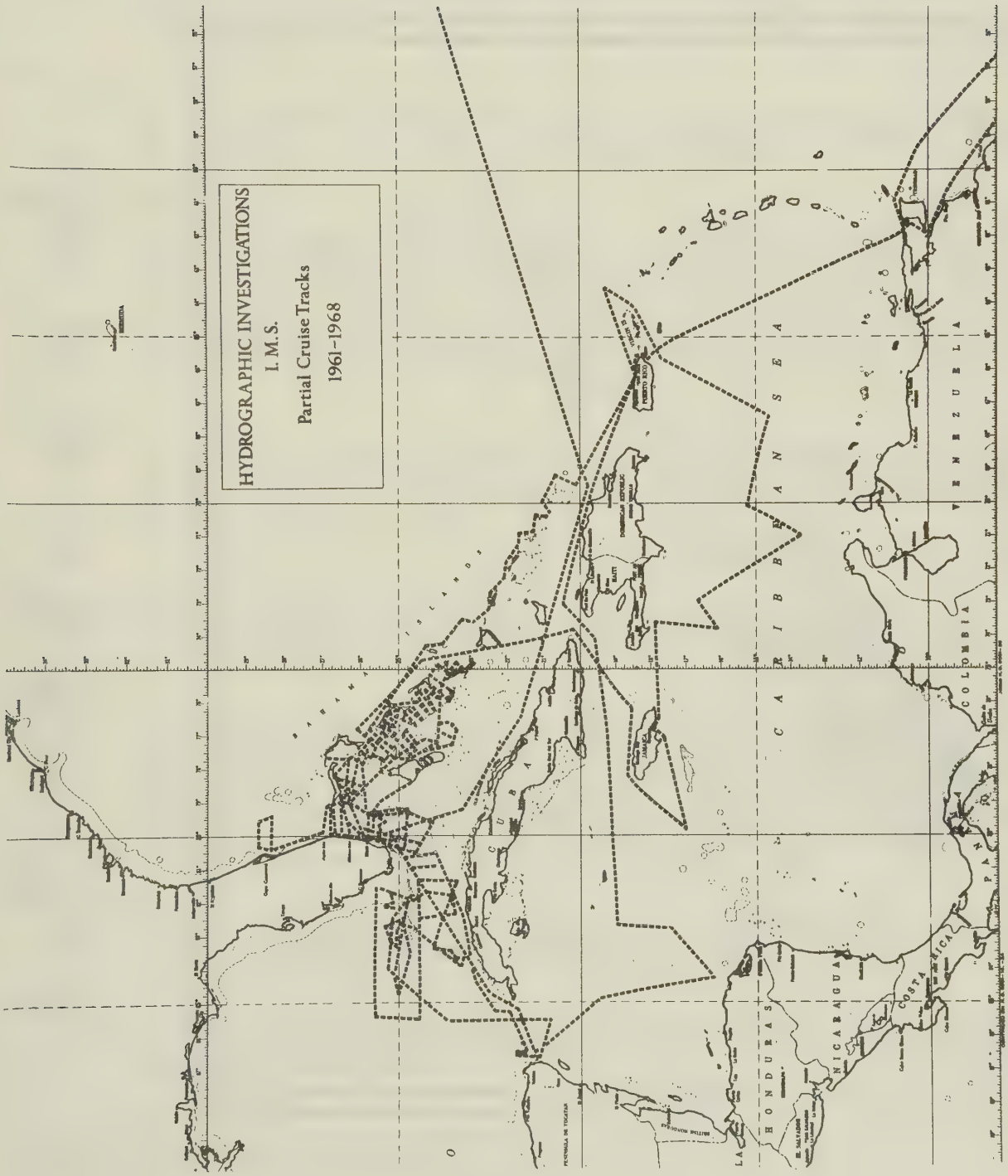

Fig. 20 Hydrographic Investigations. Partial cruise tracks, Institute of Marine Sciences, 1961-1968.

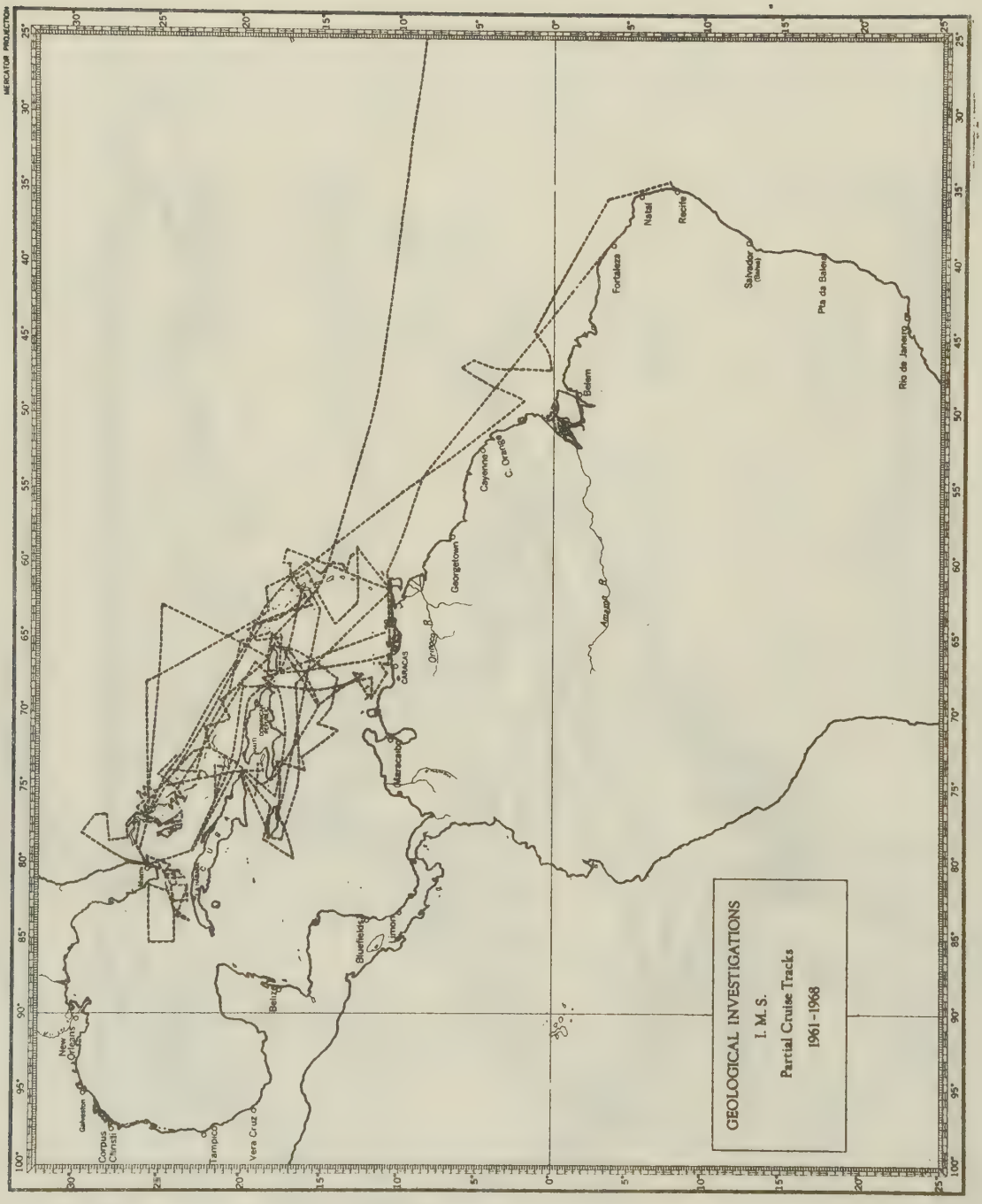

Fig. 21 Geological Investigations. Partial cruise tracks, Institute of Marine Sciences, 1961-1968.

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ANNEX 4

AUTHOR INDEX AND TITLES OF PAPERS

SECTION I - PHYSICAL AND CHEMICAL OCEANOGRAPHY

Author	Title	Abstract No.	Page No.
Anderson, N.R. and J.R. Jadamec	Strontium and Barium distributions in the Caribbean Sea	1.28	114
Aragno, F.J.	Dynamics of the Caribbean Sea in the Venezuelan coast region	1.9	104
Aragno, F.J.	Spreading of the waters of the Orinoco River into the Southeastern Caribbean Sea	1.11	105
Brucks, J.T.	The current east of the Windward Islands, West Indies	1.6	103
Castelán, S.S.	Theoretical research on hurricanes conducted with the use of electronic computers	1.22	111
Curra, R.A.	The coastal lagoons of Venezuela	1.12	105
Curra, R.A.	Present status of the oceanographic investigations in Venezuela	1.14	106
Duarte, M.P. and H.C. Ochoa	A study of the thunderstorm which occurred in the city of Caracas and the coastal area of Guaireño on 24 October 1967	1.10	105
Emilsson, I.	On the upper layer circulation in the Cayman Sea	1.4	102
Emilsson, I. and J.A. Gómez	The net of standard stations around Cuba. Some results of the first three cruises	1.18	105
Emilsson, I., J. Tapanes and J. Godoy	Contribution to the hydrography of the insular shelf off the Cuban south coast	1.17	108
Fukuoka, J.	General circulation of currents and characteristics of upwelling in the Caribbean Sea	1.2	101
Gentry, R.C.	Hurricanes - one of the major features of air-sea interaction in the Caribbean Sea	1.19	109
Giese, G.S.	Physical measurements of the coastal water south of western Puerto Rico	1.8	103
Goulet, J.R.	Currents off the eastern bulge of Brazil - A preliminary report	1.7	103
Johannessen, O.M.	Preliminary results of some oceanographical observations between Barbados and Tobago	1.15	106
Leming, T.D.	Eddies West of the Southern Lesser Antilles	1.5	102
Lettau, B.	Small-scale sea air energy characteristics in the tropics	1.24	112
Linnenbom, V.J. and J.W. Swinnerton	The Cariaco Trench - distribution of low-molecular-weight hydrocarbons	1.27	114

Author	Title	Abstract No.	Page No.
McFadden, J.D.	Airborne investigation of the effects of hurricanes on the thermal structure of the surface layers of the ocean	1.21	111
Moretti, J.E. and K. Hubschman	Study of the interchange of heat between the ocean and the atmosphere	1.25	113
Ochoa, H.C. and M.P. Duarte	The climate of the Antilles coast of Venezuela	1.13	106
Okuda, T.	Hydrographic and chemical characteristics of the Cariaco Trench	1.26	113
Ostapoff, F.	Ocean-atmosphere interaction in the area viewed from the oceanographic side	1.23	111
Perlroth, I.	Distribution of mass in the near surface waters of the Caribbean	1.3	101
Ross, C.K. and C.R. Mann	Oceanographic observations in the Jungfern Passage and over the sill into the Venezuelan Basin, February 1968	1.16	107
Simpson, R.H.	Role of the sea-air interface in the growth of hurricanes	1.20	110
Worthington, L.V.	Water circulation in the Caribbean Sea and its relationship to North Atlantic circulation	1.1	101
	SECTION II - MARINE GEOLOGY AND GEOPHYSICS		
Allersma, E.	Mud on the oceanic shelf of Guyana	2.7	119
Arden, D.D.	Petroleum prospecting in the Caribbean area	2.16	125
Avdeev, A.I. and I.M. Beloussev	On the geomorphology of the Caribbean Sea and the Gulf of Mexico	2.1	115
Bouma, A.H. and W.R. Bryant	Review of geology and geophysics of the Gulf of Mexico as it relates to the G.E.P. programme	2.13	123
Coutinho, P.N. and J.O. de Morais	Sediment distribution on the continental platform of northern north-eastern Brazil	2.10	121
Donnelly, T.W.	Geophysics of the Caribbean and adjacent areas: a synthesis of magnetic and seismic refraction results	2.14	124
Feo-Codecido, G.	The Paraguaná Peninsula; geology and natural resources	2.11	122
Garrison, L.E. and M.W. Buell, Jr.	Sea-floor structure of the Eastern Greater Antilles	2.2	115
Lagaay, R.A.	The gravity field of the southern Caribbean	2.15	125
Mac Gillavry, H.J.	Review of the geologic history of the Caribbean	2.4	116

Author	Title	Abstract No.	Page No.
Maloney, N.J.	Surface sediment facies of the continental margin off eastern Venezuela	2.8	119
Maloney, N.J.	Continental margin off central Venezuela	2.9	120
Marlowe, J.I., K.M. Kranck and C.R. Mann	Research by the Atlantic Oceanographic Laboratory, Bedford Institute, in the Caribbean area during 1968	2.12	123
Nesteroff, W.D.	Recent sediments of the Caribbean and Adjacent Regions	2.6	118
Sellier de Civrieux, J.M.	Submarine canyons in front of the Cordillera de la Costa of Venezuela	2.3	116
Sellier de Civrieux, J.M.	Distribution of the foraminifera of the emerged and submerged Holocene of the Cumaná region, Venezuela	2.5	118
	SECTION III - MARINE BIOLOGY		
Balech, E.	Dinoflagellates and tintinnids of the Gulf of Mexico and Caribbean compared with the Equatorial Atlantic area	3.9	131
Ballester, A.	Periodicity in the distribution of nutrients in the region of the Cariaco Trench	3.3	128
Björnberg, T.K.S.	Distribution of plankton in relation to the general circulation system in the area of the Caribbean Sea and adjacent waters	3.2	128
Böhm, E.L.	Calcification in the calcareous alga Halimeda opuntia (L) (Chlorophyta, Udoteaceae)	3.16	135
Brattström, H.	Nordic marine biological investigations in the Bahamas and in Florida	3.18	136
Borda, L.O.	Recent Colombian progress in the field of marine biology	3.21	137
Bullis, H.R. and L.R. Rivas	Zoogeography of the deep-sea fish genus Bathypterois in the western Atlantic	3.25	139
de la Cruz S., A.	Plankton studies in Campeche Bank	3.6	129
Díaz-Piferrer, M.	Distribution of the marine benthic flora of the Caribbean Sea	3.12	133
Elizarov, A., N. Bessonov and O. González	Results of Cuban-Soviet investigations on Campeche Bank area	3.7	130
Fergusson Wood, E.J.	Phytoplankton distribution in the Caribbean region	3.8	130
Figueroa, A.V.	Ecological studies on a coral reef at Veracruz, Mexico	3.22	137

Author	Title	Abstract No.	Page No.
Gamboa, B.R.	Distribution of nutrients on the north-eastern coast of Venezuela	3.4	129
Ganesan, E.K.	Studies on the morphology, anatomy, reproduction and taxonomy of some Caribbean crustose corallinaceae	3.23	138
González, D. and G. González	Contributions to the bibliography on marine science of the Southern Caribbean, marine biology and fisheries	3.27	139
Goodbody, I.M. and J.L. Munro	Biological investigations off the east coast of Jamaica	3.19	136
Guitart Manday, D.J.	Trapeze-like gear, a new system for rigging ichthyoplankton nets	3.11	132
Hammer, L.	A comparison of the Phytobenthos flora between the Caribbean and Mediterranean Seas	3.13	133
Hubbs, C.L.	Need for thorough inventory of tropical American marine biotas before completion of inter-oceanic sealevel canal	3.28	140
Joly, A.B. and E.C. de Oliveira Filho	The female gametophyte of Dohrniella antillarium var. brasiliensis	3.14	134
Kaufmann, R.	A new research centre in Santa Marta, Colombia	3.26	139
Liddle, L.B.	Reproduction in the brown alga Zonaria farlowii	3.15	134
López, M.L.	Distribution of the benthic macrofauna and its relationship with some physical and chemical characteristics of the sediments of the Cariaco Gulf	3.17	135
Margalef, R.	Pelagic ecosystem in the area	3.1	127
Miller, G.C.	A revision of Zoogeographical regions in the warm water area of the Western Atlantic	3.29	141
Munro, J.L. and I.M. Goodbody	The mesobenthic fauna of the Jamaica Rise	3.20	137
Owre, H.B. and M. Foyo	Studies on the Zooplankton of the Caribbean Sea	3.10	132
Rass, T.S.	Deep-water fish of the Caribbean Sea and the Gulf of Mexico	3.24	138
Steven, D.M.	Productivity cycles off Jamaica and Barbados	3.5	129

SECTION IV - FISHERY RESOURCES

Author	Title	Abstract No.	Page No.
Alvarez, G.S.	On the biology of the lobster in Cuba	4.25	154
Berry, F.H.	Taxonomic status of western Atlantic clupeid fishes	4.11	146
Bessonov, N., A. Elizarov and H.A. Santana	Results of the oceanographic investigations made at Bahía di Cienfuegos in October 1967 seen in relation to prawn distribution	4.21	152
Buesa Más, R.J. and M.I. Mota Alves	Colour scale for the study of the cycle of reproduction of the langosta in the Caribbean Sea area	4.24	154
Bullis, H.R. and C.M. Roithmayr	Observations on nightlight fish attraction and experimental fish pumping in the eastern Caribbean Sea	4.13	147
Bullis, H.R. and J.R. Thompson	A general resumé of Oregon Caribbean fishery exploration, 1956-67	4.38	161
Carpenter, J.S. and W.R. Nelson	Fishery potential for snapper and grouper in the Caribbean Sea and adjacent South American coast	4.16	149
Carr, A.	Sea turtle resources of the Caribbean and Gulf of Mexico	4.37	160
Dragovich, A.	Observations on the food of skipjack tuna in the Eastern Caribbean	4.8	144
Durant, F. and W. Brandhorst	The demersal fish resources of Venezuela and their present exploitation	4.17	150
Ewald, J.J.	The state of the shrimp resources in Venezuela	4.19	151
Ferrer, A.A.	A comparative study of some morphometric characters of the anchoveta Cetengraulis edentulus (Cuvier, 1829) from 1962 to 1965 in eastern Venezuela	4.14	147
Fourmanoir, P.	Sharks of the Guianas	4.36	160
Ginés, Hno., P. Cervigón and R. Gómez	Exploratory fishing on the north and north-east coast of South America	4.43	163
Gonzalez Cardulís, J.R. and D. Guitart Manday	Fishery explorations and connected oceano-graphical research in Cuba	4.42	163
Griffiths, R.C.	The tuna fisheries of Venezuela, with notes on other scombroids of potential commercial value	4.5	143
Gunter, G.	The molluscan resources of the Gulf of Mexico and of the south-eastern United States	4.29	157
Hayasi, S. and M. Honma	Assessment of the yellowfin stocks in the Atlantic Ocean	4.4	143

Author	Title	Abstract No.	Page No.
Honma, M. and K. Hisada	Population structure of the yellowfin tuna	4.3	142
Idyll, C.P.	Spiny lobster fishery in the Caribbean	4.23	154
Lindner, M.J.	Shrimp resources of the Caribbean Sea and adjacent regions	4.18	151
Lindner, M.J. and H.L. Cook	Progress in shrimp mariculture in the United States	4.22	153
Maghan, B.W.	The blackfin tuna (Thunnus atlanticus) as an unutilized fishery resource in the tropical western Atlantic	4.6	144
Martinez Escarbassiere, R.	Status of the biology and culture of molluscs in Venezuela	4.28	156
Menzel, R.W.	The possibility of molluscan mariculture in the Caribbean	4.27	156
Nikolíc, M. and J.S. Bofill	Some biological observations on the mangrove oyster	4.31	158
Nikolíc, M. and S.J.A. Meléndez	Exploitation of the mangrove oyster and the possibilities for its culture	4.30	157
Olguín, M. and M.E. Ruiz de Quevedo B.	Observations on the biology and fishing of white prawn	4.20	152
Pease, N.L. and K. Drennan	Aerial photo reconnaissance of surface schooling fish	4.41	162
Pinto Paiva, M. and F. Cervigón	Fishery resources on the northeast coast of South America	4.44	165
Rathjen, W.F.	Exploratory fishing activities - UNDP/FAO Caribbean Fisheries Development Project	4.39	161
Robins, C.R.	Distributional patterns of fishes from coastal and shelf waters of the tropical western Atlantic	4.15	148
Rorholm, N. and N. Marshall	Analysis and development of the marine resources of a region	4.40	162
Ruiz, J.B.	Comparative study of the chemical composition of mangrove oyster in different localities of the east coast of Venezuela	4.32	158
Simpson, J.G.	The present status of the investigation and exploitation of the clupeoid resources of Venezuela	4.12	146
Suárez A., G. and R. Xiqués Díaz	Physiological aspects of some marine invertebrates of commercial interest in Cuba	4.26	155
Tibbo, S.N. and L.M. Lauzier	Distribution of post-larval swordfish Xiphias gladius L. in relation to water masses	4.10	145
Ueyanagi, S.	Larval distribution of tunas and billfishes in the Atlantic Ocean	4.9	145

Author	Title	Abstract No.	Page No.
Urosa, L.J.	Identification of some predators of the mussel (Perna perna) under experimental conditions	4.34	159
Vélez, A.	Experimental cultures of oysters on the east coast of Venezuela	4.33	159
Voss, G.L.	The cephalopod resources of the Caribbean Sea and adjacent regions	4.35	160
Wise, J.P. and W.W. Fox, Jr.	Dynamics of the yellowfin tuna fishery of the Caribbean region	4.2	142
Wise, J.P. and A.C. Jones	Tunas and tuna fisheries of the Caribbean region	4.1	142
Yurov, V. and H. R. Ramos	Oceanographic investigations applied to the tuna fishing in the Caribbean Sea	4.7	144

ANNEX 5

ABSTRACTS OF PAPERS

Section I - Physical and Chemical Oceanography

No. 1.1

Water circulation in the Caribbean Sea and its relationship to North Atlantic circulation

by

L.V. Worthington
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

The sources of Caribbean sea water are the passages between the Greater and Lesser Antilles through which Atlantic water enters. Evidence is presented that the deepest sources are inactive at the present time. The water mass characteristics suggest that most of the water which passes through the Caribbean Sea enters through the northern passages between the Greater Antilles, but dynamic computations suggest that it should enter through the southern passages between the Lesser Antilles. A method of resolving this dilemma is proposed.

No. 1.2

General circulation of currents and characteristics of upwelling in the Caribbean Sea

by

Jiro Fukuoka
Instituto Oceanográfico
Universidad de Oriente
Cumaná

In the Caribbean Sea, close to the Venezuelan coast, there is a strong current which has some branches of counter currents and also upwelling.

In this work a study is made of the upwelling which occurs in the narrow zone between the Continent and Margarita Island and along the Peninsula of Araya and Paria. Almost the same phenomena were observed in both of these areas. It is also thought that the same mechanism of upwelling occurs in the system of the Equatorial Current.

No. 1.3

Distribution of mass in the near surface waters of the Caribbean

by

Irving Perlroth
National Oceanographic Data Center
Washington, D.C.

This study was performed in order to relate the distribution of mass in the near surface waters of the Caribbean to an historical depiction of surface currents, sea surface temperatures, and thermocline depths.

A computer programme was developed to determine the depth of the top of the thermocline using geosorted magnetic tapes of digitized bathythermograph data. A vertical temperature gradient programme consisting of a summary of ΔT's for each discrete 20 metre depth interval (surface to 260 metres) was also generated. A set of control cards is initiated from an analysis of the ΔT gradients to extract the thermocline depths.

Results of the analysis of surface currents show seasonal evidence of cyclonic and anticyclonic currents shifts adjacent to the east-west orientation of the Caribbean Current.

The large gaps in the distribution of bathythermograph data in the Yucatan, and Columbia Basins prohibit adequate examination of the seasonal variations of thermal structures.

No. 1.4 On the upper layer circulation in the Cayman Sea

by

Ingvar Emilsson
UNESCO/UNDP, Institute of Oceanology, Havana

In this paper the name Cayman Sea is used for that portion of the Central American Seas which extends from the Honduras - Jamaica-Haiti ridge towards the Yucatan Peninsula and Cuba. The circulation in the upper layer (approx. 200 meters) of the Cayman Sea is reviewed and discussed on the basis of available data.

Compared with the Mexican Gulf and the Caribbean proper, the Cayman Sea is quite irregular both as regards the coastal line and the bottom relief. It is considered that this irregular topography should have important effects upon the flow and the water mixing, in particular, in the area between Jamaica and Honduras.

A map indicating our knowledge of the surface currents is presented. It is pointed out that on both sides of the main flow of the Caribbean Current gyres and countercurrents of irregular courses and duration may appear. The variation in the wind field is considered the principal cause of changes in the flow between the Cayman Sea and the adjacent water bodies. The intermediate position of the Cayman Sea in relation with the surrounding regions of the Gulf, the Caribbean proper and the Atlantic is emphasized. It is shown that the appearance of high-velocity current in the west side of the Yucatan Channel can be attributed to the conservation of potential vorticity and it is postulated that this principle should also hold at other points along the Caribbean Current.

The possible existence of a south-going undercurrent at the west side of the Yucatan Channel, as indicated by recent investigations carried out by Soviet expeditions in the area, is commented upon. Notes on the vertical circulation are presented and areas of probable horizontal convergence and divergence are indicated.

No. 1.5 Eddies West of the Southern Lesser Antilles

by

Thomas D. Leming
Bureau of Commercial Fisheries
Tropical Atlantic Biological Laboratory, Miami

The hydrographic structure of two eddies found just west of St. Vincent and St. Lucia, British West Indies is described. An anticyclonic vortex found in September 1965, extends from the surface to about 75 m and is accompanied by temperature increases of 2.0°C in about 2 weeks. A cyclonic eddy found in April 1966, extends from the surface to about 300 m. Geostrophic velocity calculations within the eddy give surface speeds in the 80-100 cm/sec range while at 200 m the speeds are 6-10 cm/sec. A possible generating mechanism for the eddy is discussed. Potential nutrient enrichment and localization are discussed also.

No. 1.6 The current east of the Windward Islands, West Indies

by

John T. Brucks
Bureau of Commercial Fisheries
Tropical Atlantic Biological Laboratory, Miami

Oceanographic data collected in the region east of the Windward Islands reveal variations in the current not evident in atlases of average conditions. As portrayed by drift bottle tracks and horizontal and vertical sections of temperature and dynamic height, the current is shown to vary widely in speed, direction, depth, and state of turbulence.

No. 1.7 Currents off the eastern bulge of Brazil - A preliminary report

by

Julien R. Goulet, Jr.
Oceanographer, Bureau of Commercial Fisheries
Tropical Atlantic Biological Laboratory, Miami

Characteristic diagrams of temperature versus salinity showed that the surface layers adjacent to the eastern bulge of Brazil could be separated into two water masses, one of salinities approximately 0.43°/oo higher than the other on and near the layer of maximum salinity. On the 294 cl/t isothermosteric surface, average salinities were 36.95°/oo in the south and west, and 36.52°/oo in the north and east. High salinities are characteristic of the Brazil Current and the salt branch of the South Equatorial Current, while low salinities are characteristic of the fresh branch of the South Equatorial Current. Flow patterns estimated from the slope of isothermosteric surfaces showed that the waters adjacent to the eastern bulge of Brazil were dominated by the South Equatorial Current and by the origins of the Brazil and Guyana Currents.

No. 1.8 Physical measurements of the coastal water south of western Puerto Rico

by

Graham S. Giese
University of Puerto Rico, Department of Marine Sciences
Mayaguez, Puerto Rico

Eleven percent of the surface area of the Caribbean Sea consists of coastal waters less than 100 m deep. This water overlies flat shelves which vary in width and depth but which are similar in the respect that they all terminate in steep slopes and that almost everywhere the shelf edge is above the 100 m contour.

The shallowness of this water, together with the fact that it lies between land areas on one side and deep basins on the other, gives it great and growing economic importance. Land drainage, wave stirring of the bottom sediments, deep light penetration and, frequently, upwelling at the shelf edge enhance the biological productivity of the coastal water which supports a large part of the Caribbean fishing industry. In addition to the part they play in fish and shellfish production, vast reef assemblages are often important for coastal protection and are becoming increasingly valuable for recreational purposes, as are beaches and nearshore areas. On the other hand, these shelves are of growing importance for their mineral resources. In particular, the suction dredging of sand deposits formed during the Pleistocene periods of low sea level is likely to increase greatly in the near future to supply the needs of the many growing Caribbean communities presently deficient in building materials. In addition, industrial development along many coasts is leading to the increased dumping of industrial wastes into the coastal water.

Clearly, these varied uses of the shelves and coastal waters will often be in conflict with each other. In order to achieve the maximum prudent utilization of the coastal waters of the Caribbean

Sea it is imperative that the physical processes and properties of this water be well understood. Detailed studies must be made of the general circulation, both advection and mixing, of sediment transportation, and of nearshore processes. The effects of winds, waves, tides, land runoff and the open Caribbean currents must be ascertained. To this end, the distributions of salinity, temperature, oxygen and nutriets within the coastal water must be determined.

A review of the literature reveals that most of the coastal physical oceanography in the Caribbean Sea has been concerned with the north coast of South America.

The need exists for similar studies of other Caribbean coastal waters with an extended time base to ensure inclusion of seasonal variations, and for the coordination of such studies with those of biological and geological parameters.

No. 1.9

Dynamics of the Caribbean Sea in the Venezuelan coast region

by

Federico J. Aragno
Marine Research Station of Margarita
La Salle Foundation for Natural Sciences, Caracas

The general distribution of surface temperature does not indicate very significant characteristics, except a low temperature nucleus - 25° to 27°C, centered around Margarita Island. In the remaining Venezuelan Coast, the surface temperature reaches the usual values of the region, 27.5° to 29°C.

The vertical distribution of the temperature shows very stratified layers with the distribution that seems to be characteristic in the edges of the continental shelves, that is, the isotherms indicate the upwelling effect; this upwelling decreases towards the west of the Eastern Venezuelan Continental Shelf. In the Cariaco Trench strong temperature gradients are observed near the surface, corresponding to the position of the sill; these gradients decrease with depth, which makes renewal of the water in the basin very difficult.

Distribution of salinity on the surface is much more characteristic than that of temperature, since it indicates towards the west, the flowing of the Orinoco river.

As regards the vertical diagram distribution of salinity, the statement for temperature is confirmed.

With reference to the dynamics, two anticyclonic centers are observed which, while producing in several places currents in opposite directions, due to the Langmuir effect, derive a vertical component which produces an upwelling of lower temperature water rich in nutrients.

The above also explains the strong temperature gradients near the surface, which correspond to the Cariaco's Trench sill.

These anticyclonic systems, taking also into consideration the mass balance, give a reason for the high salinity of the water nucleus, some of which proceed, in depth, from the north, and others, from the coast.

No. 1.10 A study of the thunderstorm which occurred in the city of Caracas and the coastal area of Guaireño on 24 October 1967

by

Moris Pieve Duarte and Hudo Casale Ochoa
Ministerio de la Defensa
Dirección de Hidrografía y Navegación, Caracas

On 24 October 1967, between 12.09 and 13.10 hours local Venezuelan time a violent thunderstorm occurred in the city of Caracas and the coastal area of Guaireño. It is important to study the causes of this meteorological phenomenon which occurs very infrequently in these latitudes.

An analogy of the synoptic charts for the days immediately preceding 24 October was made with special reference to the zone between 5°N and 30°N lat. and 35°W and 85°W long. The first abnormality was observed on 16 October when, in the surface chart, a low pressure started moving westwards. The track of this displacement could be followed, and in the synoptic chart of the surface for 12.00 hours on 24 October, the low pressure was found over the affected zones.

During the period of the actual thunderstorm a marked reduction of temperature was observed. For a period of one hour and 24 minutes it fell 13.4°C. The total precipitation during this thunderstorm was 49.8 mm of rain and the highest intensity was 104 mm per hour, in a time period of 5 minutes. During this period, squalls with maximum velocity of 86.4 km/hour were recorded.

It is concluded that this meteorological phenomenon was caused by the presence, in the affected zone, of a low pressure associated with a mass of cold air higher up.

No. 1.11 Spreading of the waters of the Orinoco River into the Southeastern Caribbean Sea

by

Federico J. Aragno
Marine Research Station of Margarita
La Salle Foundation for Natural Sciences, Caracas

As the T-S diagram is used to identify water masses in the open seas and also to establish the proportion of the mixture of different waters, the S - Si plotting, when it follows a linear distribution, could be an indication of the presence of fresh water from rivers near its mouths, where mixture between fresh and sea water is important because of its contents of nutrient salts. Also, from a dynamic point of view, to establish the mixture zone at the mouth of the river will give an idea of the discharge of fresh water and therefore a general scheme of the circulation at the mouth of the river and adjacent zones.

In the particular situation under consideration, the spreading of the Orinoco River into the Caribbean Sea, it is observed that the waters of the river have very little influence towards the east of its mouth, while the main flow goes towards the west, which is sustained by the general circulation of the zone, from southeast to northwest.

No. 1.12 The coastal lagoons of Venezuela

by

Rafael A. Curra
Instituto Oceanográfico
Universidad de Oriente, Cumaná

Venezuela has an interesting complex of coastal lagoons along its extensive Caribbean coast. In this category we can include the following masses of water: Carenero, Tacarigua, Unare, Píritu, Los Patos, Chacopata, Arestinga, Marites, Campoma and Guariquen.

The physical-chemical and hydrobiological characteristics of these waters differ, but they have in common an abundance of nutrients that makes them potentially rich as areas of high biological productivity.

In this paper a general analysis of the coastal lagoons of Venezuela is presented, indicating at the same time their location, area, and fishery potential. A review of past research and programmes presently under way is also given as well as a bibliography covering the subject.

No. 1.13 The climate of the Antilles coast of Venezuela

by

Hugo Casale Ochoa and Moris Pieve Duarte
Ministerio de la Defensa
Dirección de Hidrografía y Navegación, Caracas

This work is based on data from the meteorological stations on the Venezuelan coast, Curaçao and Trinidad. Variations of different meteorological parameters were analysed and a comparison made between coastal stations and also with purely continental observations such as those from the Maracay station. From these analyses it is evident that this zone, like all maritime climates, is characterised by small temperature variations, both diurnal and annual.

In addition to the temperature, for which an average of 27°C was estimated, the relative humidity can be mentioned. This was found to have an average of 78%. As expected, the relative humidity showed greater fluctuations in continental stations than on the coast.

With regard to the precipitation on the Venezuelan coast, it is very scarce, due to the prevailing north-east wind. Nevertheless, at certain periods, and especially during the winter, rains are both heavy and of long duration. These are associated with very diffused cold fronts moving in from the north.

No. 1.14 Present status of the oceanographic investigations in Venezuela

by

Rafael A. Curra
Instituto Oceanográfico
Universidad de Oriente, Cumaná

In the present paper the physical and human resources of the oceanographic investigations are reviewed. The basic objectives of different marine laboratories in Venezuela are described, along with the financial characteristics of the investigations and the possibilities of establishing a National Committee on Oceanography, and a National Programme of Oceanographic Research.

No. 1.15 Preliminary results of some oceanographical observations between Barbados and Tobago

by

Ola M. Johannessen
Marine Sciences Centre
McGill University, Montreal

An investigation of physical and biological oceanography was carried out by Marine Sciences Centre, McGill University with the Canadian Research Vessel Hudson, Bedford Institute, in a section between Barbados and Tobago 24 March - 2 April 1968. Some of the preliminary results from the physical programme, which occupied half of the total observation period is reported.

The section shows that the isotherms, isochalines and isopycnals have a general slope upwards going from Barbados to Tobago, with the largest slope over the continental slope on the Tobago side. S.T.D. observations using a German Bathysonde shows that the fine structure is well developed in the area.

A moored buoy system was used during a 3 days period 50 nautical miles east of Tobago anchored on 1,630 m. Current metres, Bergen type, were set in 15 m, 100 m (sub-tropical water), 800 m (Antarctic intermediate water), and 10 m above bottom. However, after one day, the buoy system was set slowly adrift and only data from 15 and 100 metres were recovered. (Current metre in 800 m flooded and current metre 10 m above the bottom lost).

The diurnal and semidiurnal tidal current was of the same magnitude, 15-5 cm/s respectively for the major and minor axis. The amplitude was higher in the 100 m level. Rotation of the tidal current was counter clockwise at 15 m and clockwise at 100 m level. This may be explained by reflection of the tidal wave in the surface layer due to the complex bathymetry in the area.

The daily averaged current velocity showed little variation in speed and direction. The direction of the current was towards 300 degrees and the speed in the 100 m level about 50 cm/s for each of the days. However, the speed at 15 m level increased from 50 cm/s to 75 cm/s during the three days period.

Simultaneously S.T.D. observations by the Bathysonde about every hour showed that internal oscillations of tidal periods were present. In the upper level down to 300 m, the oscillations were quite small with characteristic amplitudes of 5-10 m for both the diurnal and semi-diurnal periods, however, increasing to about 20-40 m at a depth of 600-700 m. B.T. observations off Barbados and Tobago also showed the existence of similar internal oscillations.

Volume transport calculation was performed using the 1000 db level as reference surface of no motion and a value of 24.10^6 m^3/s was obtained. This is 80% of the meridional volume transport in the Caribbean Sea.

No. 1.16

Oceanographic observations in the Jungfern Passage and over the sill into the Venezuelan Basin, February 1968

by

C.K. Ross and C.R. Mann
Atlantic Oceanographic Laboratories
Bedford Institute, Dartmouth, Nova Scotia

A series of temperature and salinity measurements were made in the deep part of the channel in the Jungfern Passage through into the Venezuelan Basin. Water with a potential temperature of 3.70°C was found on top of a sill (1,850 m) at the entrance to the Venezuelan Basin. Two miles farther into the Basin bottom temperatures at a depth of 2,500 m were 3.85°C. There was no evidence of the colder, heavier, water cascading into the Basin to form bottom water.

No. 1.17 Contribution to the hydrography of the insular shelf off the Cuban south coast

by

Ingvar Emilsson
UNESCO/UNDP, Instituto de Oceanología, Havana

Juan Tapanes
Centro de Investigaciones Pesqueras, Havana

and

Jacinto Godoy
Instituto de Oceanología, Havana

The insular shelf that borders the south coast of Cuba represents an area of considerable extension (40,000 km^2), however of very shallow depth (5–15 m). The outer border of this shelf is fringed by lines of keys and shallows which to a certain degree limit the communication with the open ocean. On the shelf itself a number of small islands and shallows also form obstacles to the water circulation. The data used for the statistical treatment consists of about 570 observations of temperature and 460 of salinity. Mean values as well as maxima and minima were calculated for both temperature and salinity in the various sub-regions and for the four seasons of the year.

The annual surface temperature curve for the open sea is compared with the seasonal values for the shelf. In the open sea, the maximum temperature is about 26°C in January-February. Over the shelf, the corresponding mean values are 31°C in July and 25°C in January. The comparison of salinity on the shelf and in the open sea shows that, while in the latter the surface values are close to 36°/oo the year around, the salinity on the shelf suffers a considerable variation. As a rule, the salinity of the water reaches its highest values in spring and values as high as 40°/oo may be found in places where the evaporation is the dominating factor. The lowest salinities occur in autumn and winter when extensive areas near the main rivers show values lower than 35°/oo.

The annual T-S cycle for each sub-region is presented. As a general rule it is found that the more distant and isolated a given region is from the open sea, the larger the area enclosed by the annual curve on the T-S diagram. This simply means that the waters in regions which are remote and isolated from the sea suffer the greatest variations in respect to salinity and temperature.

The density of the shelf water, in relation to that found in the surface layer of the open sea, plays an important rôle in the interchange of water between the two media. During the winter and spring, when the relatively cool and salty shelf water has a higher density than the surface water in the open sea outside, sinking or cascading over the edge of the shelf will occur to some extent.

It is considered that, under the influence of the prevailing ENE trade wind, the shelf water is displaced westward at the rate of some 5 nautical miles per day.

No. 1.18 The net of standard stations around Cuba. Some results of the first three cruises

by

Ingvar Emilsson
UNESCO/UNDP(EPTA), Instituto de Oceanología, Havana

and

José A. Gómez

As part of a general plan to investigate the environmental conditions in the waters near Cuba, a net of standard oceanographic stations has been established in this area. The system consists basically of some 60 stations order in sections that cross the passageways separating the Island from the neighbouring lands, islands and banks (the Windward Passage, Yucatan Channel, etc.)

Since August 1966 to date (November 1968), four cruises have been carried out for this purpose. The work involves mainly:

- Hydrocasts with 15 bottles at standard depths down to 900 m.

- Plankton sampling in the upper 150 m.

- Surface current observations along the route by means of a G.E.K. system.

The section across the Florida Straits (Havana Section) is customarily taken both at the start and at the end of each cruise, so as to check the changes that have occurred during this lapse of time (about 25 days). The results show that the water structure in the upper 300 m of this important section may suffer considerable changes over a short period. One of the causes of these variations has its roots in the strong north winds (the "northers") that blow periodically over this region during winter.

In the summer season, the surface temperature reaches 29°C, decreasing gradually with depth and passing 25°C at around 100 m. During winter a mixed homothermal surface layer is formed, the depth of which may reach some 130 m in the western and 80 m in the eastern part of the region. The thickness of this homothermal layer is probably related to the process of horizontal divergence and convergence in the surface layer.

On all stations near the Cuban coast an intermediate salinity - maximum layer is observed, which can be adequately defined as consisting of water masses of salinity above 36.5°/oo and temperature between 17.5°C. Apparently the lower limit of this layer (17.5°C and 36.5°/oo) is maintained at a stable depth the year round, at 200-250 m near the north coast and about 300 m at the south coast. The depth of the upper limit shows a relatively greater variation; in summer it can be found at about 100 m when in winter it occasionally rises to the surface.

Normally, the maximum salinity in the intermediate layer lies between 36.7°/oo and 36.8°/oo. Values above 37.0°/oo have, however, been observed on several occasions. In the salinity maximum, one finds usually a more or less accentuated relative minimum of oxygen. On various occasions an abnormal T-S relation has been observed below the salinity maximum layer. It is suggested that one of the possible causes of this phenomenon could be cascading of high salinity water which is formed during winter and spring over the shallow areas near Cuba and the Bahamas.

No. 1.19

Hurricanes - one of the major features of air-sea interaction in the Caribbean Sea

by

R. Cecil Gentry
National Hurricane Research Laboratory
Environmental Science Services Administration, Miami

Hurricanes are marine storms. They form over the oceans and obtain their energy from oceanic sources. They, in turn, have major effects on the ocean by inducing large movements of the ocean water.

Hurricanes are uniquely a product of an oceanic environment, and they begin to dissipate once they are cut off from the energy contained in the warm tropical oceans. This happens when the storms move either over land or colder water. The hurricane's primary source of energy is the latent heat that is released as the warm moist tropical air flows upward through the hurricane circulation. This moisture in the air originally comes from the ocean and about 75% of it is already in the air drawn into the hurricane circulation. The remainder evaporates from the sea in situ, i.e., into the air after it has already entered the storm's circulation. A secondary, but also important, source of energy is the sensible heat transferred from the ocean to the atmosphere inside the hurricane. The hurricane converts the heat energy acquired from the various sources first into potential energy, and later a small portion into kinetic energy.

While the quantity of the sensible and latent heat transferred to the air from the ocean beneath the hurricane is less than that already in the air that crosses the lateral boundaries of the storm, it effectively determines the intensity of the storm. A tropical cyclone can reach only minimum hurricane intensity (winds of about 32 m per second) if the only energy available to it is that stored in the air normally found in the tropics. Research during the past few years strongly supports the hypothesis that intensification of the storm beyond that of a minimum hurricane is limited by

the rate at which sensible and latent heat is transferred from the ocean to the atmosphere inside the hurricane. This immediately suggests that many of the problems related to the energetics of the hurricane are related to air-sea interaction.

The effects of the hurricane on the ocean surface are well known. The high waves and tides induced by the hurricanes cause great damage along exposed coasts. When a hurricane crosses a coast, the ocean surface frequently rises 2 to 4 m above mean sea level and has risen more than 5 m in a few Caribbean hurricanes. Over the open ocean the mean water level does not rise so much, but the deficiency of atmospheric pressure over the centre of a severe hurricane often results in a mean rise in the level of the sea by more than 60 cm. In this case the waves are much more spectacular and frequently exceed 10 m in height. In extreme cases individual waves may equal or exceed 15 m.

The currents induced by the hurricane's winds cause upwelling in the vicinity of the hurricane. There have been well-documented cases where the sea temperatures of the ocean surface were more than 5°C colder after a hurricane had passed. There are probably several contributing factors to this cooling effect but the major one is believed to be the upwelling of colder water from lower levels.

The annual and monthly frequency of tropical cyclones in the Caribbean Sea and adjacent areas will also be discussed.

No. 1.20

Role of the sea-air interface in the growth of hurricanes

by

R.H. Simpson
National Hurricane Centre
ESSA Weather Bureau, Miami

One of the more interesting questions in tropical meteorology is why we do not have more hurricanes than we do. Numerous disturbances parade across the tropical oceans, but less than one tenth become tropical storms or hurricanes. This question cannot be clearly answered, but the problem is one of energetics in which the oceans are identified as the source of critical fuel for the growth process. In the chain of events in which energy supplied to a disturbance causes it to grow into a hurricane, the most interesting link is that involving the sea-air interface.

The initial growth of a disturbance depends upon the latent heat of condensation released when moist tropic ocean air entrains from a trade wind environment into a low pressure centre. The release of latent heat increases the potential energy of the disturbance, lightens the atmospheric column and causes surface pressures to fall. The consequent acceleration of air toward low pressure in the boundary layer leads to the establishment of a vertical mass circulation which in turn redistributes the potential energy and releases kinetic energy.

The latent heat energy nominally transported into a disturbance by tropic ocean air and released with the formation of rain, can reduce surface pressures little more than one percent. The resulting pressure gradients cannot sustain winds of hurricane force (32 mps). In very severe hurricanes with winds of 60 to 80 mps, the central pressure may be 8 to 10% lower than the environment. So the oceans alone can supply the additional heat energy which is critical to the growth of a mature hurricane. The processes at the sea-air interface involve a transfer of both latent and sensible heat from the ocean to the atmosphere. For these transfers to proceed effectively, the sea surface temperature, according to Palmen must not be lower than about 27°C.

The latent heat transfers from the ocean are of several kinds. First, there is evaporation from the sea surface and from the flying spray. This source, however, accounts for little more than a third the amount of latent heat imported by the storm circulation from the environment. Heat energy is extracted from the sea during an isothermal expansion at the interface as inspiralling air proceeds toward lower pressure, and as the rain cooled downdrafts near the storm centre contact the warm water surface and recycle into the cloud system.

If a hurricane is to maintain intensity, it must keep on the move to avoid a backlash from the ocean. The cold water brought to the surface by the hurricane wind stresses on the sea tend to choke off the flux of heat to the air and reduce storm intensity.

While the processes postulated above have gained general acceptance, the rapidity with which central pressures may change in hurricanes is at times difficult to account for in terms of commonly accepted values of the transfer coefficient.

No. 1.21 Airborne investigation of the effects of hurricanes on the thermal structure of the surface layers of the ocean

by

James D. McFadden
ESSA, Atlantic Oceanographic Laboratories
Sea Air Interaction Laboratory, Miami

Recent studies by a number of investigators have indicated that the circulation in a hurricane induces upwelling of colder subsurface water. There is, however, some disagreement as to where the upwelling occurs. This question is discussed with particular reference to the adequacy of the data used in reaching the various conclusions and a description is given of a recently developed airborne expendable bathythermograph which, when used in conjunction with an airborne infrared thermometer, may lead to a satisfactory solution to the problem. A description of the method of employment of these two systems in this type of study is also presented.

No. 1.22 Theoretical research on hurricanes conducted with the use of electronic computers

by

Sergio Serra Castelán
Instituto de Geoffsica
Universidad Nacional Autónoma de México

At present many questions concerning the behaviour of hurricanes remain unanswered because of the lack of adequate observations. To obtain a better understanding of the physics of hurricanes, efforts have been made to design theoretical and experimental models of these phenomena. The present paper briefly reviews progress achieved in understanding their physics by use of theoretical models of hurricanes formulated in the past and presents a new theoretical model of a symmetrical hurricane with five layers in the troposphere. In this model, basic equations in the reference system known as "p/pO" (p = pressure, pO = pressure at sea level) are used.

The release of latent heat and its partition in the troposphere is parameterized as a function of the vertical distribution of the equivalent potential temperature and, starting from an initial state assuming a hypothetical, slight tropical depression, integration is effected by use of an electronic computer, so that the form in which the "hurricane" develops is observable.

The physico-mathematical characteristics and possible usefulness of the model are considered and the findings of the preliminary numerical integration are presented with a discussion as to whether the results correspond to the known physical phenomena.

No. 1.23 Ocean-atmosphere interaction in the area viewed from the oceanographic side

by

Feodor Ostapoff
Sea-Air Interaction Laboratory, U.S. Department of Commerce, Rockville

The influence of atmospheric processes on the ocean is complex and of great magnitude, occurring on all geophysical time and space scales. It is impossible to elaborate here all of the facets and implications. Therefore, it is necessary to restrict our considerations perhaps to the most important ones in the context of this Symposium.

A brief review will be given of the large scale circulation and the distribution of water masses once formed under specific climatological conditions at the sea surface in far removed and widely separated areas and advected into the Caribbean Sea.

Then, we will describe in some detail the heat and water budget in the area on a seasonal basis and its impact on the oceanic conditions, in particular on the sea surface temperature and salinity distribution.

A numerical model on time scales of a few days combining the atmospheric and oceanic boundary layers is described with emphasis on the ocean layer. Few examples are given with climatological atmospheric and oceanic data input from the area east of Barbados at about 13°N and 56°W. The model includes the simulation of eddy fluxes in stratified flow, mixing due to wind generated waves on the sea surface and cloud-dependent radiative heating. Results will be discussed in terms of diurnal current variations, temperature variations and salinity variations.

Finally, an important aspect of ocean-atmospheric interaction in the area is the question of the effect on the ocean of extreme atmospheric forces of short duration such as a hurricane moving through the Caribbean. An example will be presented of the sea surface temperature distribution as measured in the Gulf of Mexico with IR instrumented aircraft following a hurricane. Cold water upwelling in the wake of the storm leaves a temperature signature at the sea surface. The temperature depression may amount to as much as 5°C. It is suggested that with the help of available technology and the use of aircraft important problems of time response of the ocean to atmospheric forces may be studied under partially controlled conditons. The Caribbean may be an ideal place where such a complex process may be tractable.

No. 1.24

Small-scale sea air energy characteristics in the tropics

by

B. Lettau
SAIL, AOL, ESSA, Miami

Meteorologists are generally inclined to look upon the ocean as a somewhat bothersome lower boundary to the atmosphere, whose flaw of fluidity is only partly assauged by its infinite capacity as a heat sink and moisture source, although it should be said that this quite inaccurate concept has prevailed largely because of a lack of coordinated meteorological and oceanographical measurements.

To examine the interplay between sea and air, a series of field experiments was carried out during the summer of 1968 in the region east of Barbados, which consisted in part of an attempt to establish an energy budget at the sea-air interface by actually observing the fluxes of the various energy components through the faces of a small arbitrary volume. This volume includes what has been called the "interfacial layer" of the atmosphere by Charnock and Ellison - defined as the immediate naighbourhood of the water surface - in which the vertical fluxes may be considered independent of height although the perturbing effect of surface waves must be taken into account. In the ocean it includes the depths to which relatively high-frequency variations in the atmospheric forcing functions applied at the interface are transmitted.

The experimental plan allows three primary points to be brought out in the presentation. The first is that the rôle which the ocean takes on in the energy transformation and exchange process is one of a short term reservoir of sensible energy which attenuates diurnal variations and, in the absence of mesoscale disturbances, maintains relatively constant flux levels. This, of course, is well-known, however the actual time scale involved is of interest in both synoptic meteorology and oceanography.

The second point is that by making measurements at the actual interface, within wave troughs, the concept of the oceanic surface roughness, z_o, may be examined empirically.

The third point which will be considered is whether the magnitudes of the sensible and latent heat fluxes can be parameterized in terms of the radiative energy supply at the interface, sea surface characteristics, or other conveniently measured quantities.

No. 1.25

Study of the interchange of heat between the ocean and the atmosphere

by

J.E. Moretti and Kurty Hubschman
Ministerio de la Defensa
Dirección de Hidrografía y Navegación, Caracas

This paper relates a descriptive study of the interchange of heat between the ocean and the atmosphere in the area of the Caribbean Sea close to Venezuela (principally the eastern most parts of Venezuela).

The data were obtained from Universidad de Oriente and the La Salle Foundation. Air temperature (dry and humid) observations were made with an Assmanan Psychometer while the sea temperature observations were made with reversible thermometers. Wind observations are partly estimates (in the Beaufort scale), partly observations with a Casoleta Anemometer.

The estimated Daily Evaporation (in mm/day), the latent heat and the condensation heat were calculated according to Bowens formula.

Conclusions are drawn concerning the distribution of the various parameters that are involved in the heat interchange and the influence of the heat interchange on the movement of the air masses.

No. 1.26

Hydrographic and chemical characteristics of the Cariaco Trench

by

Taizo Okuda
Instituto Oceanográfico
Universidad de Oriente, Cumaná

The Cariaco Trench is an anoxic basin which ranges in depth from approximately 400 m to 1,400 m. This paper analyses the chemical and hydrographic characteristics of the Cariaco Trench using published data of various sources as well as our own data from the years 1965-1968.

The seasonal variation of the physical parameters, such as temperature, salinity and sigma-t, were for practical purposes limited to the surface layer down to a depth of 200 m. The isopycnal surface (26.0 in sigma-t) showed, on the contrary, a great seasonal variation, with a peak in April (at a depth of 30-50 m) and gradually deepening until the month of November (140-160 m). This seasonal variation is related to the temperature and oxygen content. The rising of the isopycnal surface in April is related to the upwelling produced by the wind. It is worth noting that a maximum density (sigma-t) was sometimes observed in the layer between 400-700 m of depth. This phenomenon suggests that a mixing of water may take place in the deeper layers of the Cariaco Trench.

Oxygen content decreased rapidly with depth and disappeared in the layer of 400-500 m of depth. The maximum value for pH was 8.21 at the surface and decreased down to 7.78 at 600-700 m to increase slightly again up to 7.82 in the deepest layer (900 m). The specific alkalinity was recorded as between 0.116 and 0.127 having its highest values (0.126-0.127) at 800 m.

Phosphate content increased approximately from 100 m downwards; at 150-200 m there was a sudden increase. At 400 m the phosphate content was 2.4-2.9 μg.at/L.

Ammonia values in the upper layer were rather high; decreasing downwards to a depth of 300 m and after 350-400 m became higher again. At a depth of more than 600 m most values were between 12-17 μg.at/L. The maximum concentration of nitrite was at 30-50 m with only traces of it in waters deeper than 200 m. The nitrite was replaced by nitrate which increased with depth showing a maximum at 100-200 m. Deeper than that, the nitrate was reduced rapidly and disappeared in the layer deeper than 300 m. The maxima values for nitrate varied between 10 and 14 μg.at/L.

In the vertical distribution of total N (organic and inorganic) the minimum values were registered between 300-400 m. This is perhaps caused by the production of free N_2 in the process of identification.

No. 1.27

The Cariaco Trench - distribution of low-molecular-weight hydrocarbons

by

Victor J. Linnenbom and John W. Swinnerton
Naval Research Laboratory, Washington D.C.

This presentation is concerned with the presence and distribution of low-molecular-weight hydrocarbons in the oxygenated and anoxic waters of the Cariaco Trench. Dr. Richards in a recent paper on the distribution of methane in the marine environment has reported on the presence of methane in various anoxic water masses, the Cariaco Trench being included. He reported finding methane only in the anoxic waters. With the development of an extremely sensitive gas chromatographic methods, we have been able to make measurements of methane and other low-molecular weight hydrocarbons both in oxygenated and anoxic sea water. The method of analysis has been described in the literature.

The occurrence of several hydrocarbons are described. Concentrations of methane in the anoxic regions are greater by several orders of magnitude than in the oxygenated upper waters; this increase in concentration does not begin to appear until the level of zero oxygen concentration is reached. The concentrations of the higher saturated hydrocarbons in general show the same increase in the anoxic waters, although in all cases their concentrations are much less than methane.

It seems clear at this point that the mechanism of production in the anoxic waters involves the anaerobic decomposition of organic matter. It may be of interest to note that in the upper layers of the open ocean an entirely different mechanism of hydrocarbon production appears to exist. We note marked concentration peaks in these waters, for example, which appear to exhibit a diurnal effect; this suggests a possible correlation with biological processes. Furthermore, the unsaturated hydrocarbons are noticeably higher in concentration than the saturates, whereas in anoxic waters the reverse is true. The methane at the surface appears to be in equilibrium with the partial pressure of methane in the atmosphere.

Data will also be presented which establishes the presence of excess molecular nitrogen in the anoxic waters presumably from the reduction of nitrate ions by organic matter.

No. 1.28

Strontium and Barium distributions in the Caribbean Sea

by

Neil R. Andersen and J. Richard Jadamec
Research and Development Department
Naval Oceanographic Office, Washington, D.C.

The analyses of sea water samples from the Atlantic Ocean, by the precise method recently developed by Andersen and Hume, have demonstrated that a variation (i.e. ~3%) in the strontium/chlorinity ratio with respect to depth exists. Additionally, this variation has been tentatively shown to characterize the Antarctic Intermediate Water at the ocean stations studied in the equatorial region of the Atlantic Ocean. Barium distributions, on the other hand, have shown a much greater element to chlorinity ratio (i.e. >90%) and does not appear to be associated with any one single oceanographic parameter.

To further investigate the relationships of the strontium/chlorinity ratio to various defined water masses and large-scale circulation pattern, and characteristics of the barium/chlorinity ratio variation, analyses were conducted on sea water samples collected in the Caribbean Sea and adjacent Atlantic Ocean Waters. Four stations were occupied between Puerto Rico and Venezuela in January, 1968, where fifty-five samples of filtered sea water were collected, the last station being in the Cariaco Trench. The results of the analyses of these environmental samples in addition to those from one ocean station south of the Dominican Republic, two ocean stations seaward from the Lesser Antilles, and one station northwest of Puerto Rico are presented.

Consideration of the results is given to further develop the previously proposed hypotheses that a defined water mass possibly can be identified by the vertical profile of the strontium/chlorinity ratio due to characterization, at the origins, of this chemical variable of the water masses comprising the water column. The profiles presented specifically consider the identification of subtropical underwater (100–200 m) and Antarctic Intermediate water (600–800 m) in the Caribbean Sea and neighbouring Atlantic Ocean waters by means of the strontium/chlorinity ratio, as well as giving the vertical distributions of strontium and barium in the Cariaco Trench. The significance of the biomass in causing the observed strontium/chlorinity variations is also discussed. Further, data on barium distributions from all ocean stations occupied are also presented and discussed in relation to other oceanographic variables measured.

Section II: Marine Geology and Geophysics

No. 2.1

On the geomorphology of the Caribbean Sea and the Gulf of Mexico

by

A.I. Avdeev and I.M. Beloussev
Institute of Oceanology
Academy of Sciences of the U.S.S.R., Moscow

The study of the bottom topography is an important part in the general complex of oceanological investigations. Knowledge on this subject is necessary for geological and tectonic investigations, for studying the deep-circulation and the distribution of bottom sediments and benthos.

Rather extensive but very variable data exist on the bottom topography of this tectonically extremely interesting region. A large amount of soundings are plotted on navigational charts and plotting sheets. During the IGY new data obtained by the R/V Vema, Atlantis, Crowford and others were collected and partially published. They were also sent to the WDC. Extensive investigations were carried out by the Soviet R/V M. Lomonossov and Academician Kovalevsky. Nevertheless, as we are aware, neither detailed description of the bottom relief, nor large-scale bathymetric and geomorphological charts have been prepared.

On the basis of the material collected by Soviet expeditions with the addition of other available sources, from the Marine Hydrophysical Institute of the UKr.S.S.R. Academy of Science and the Institute of Oceanography of the U.S.S.R. Academy of Science, bathymetric charts of the Caribbean Sea, the southern Gulf of Mexico, the Cayman Trench and the Old Bahamian Channel, were compiled by the method of geomorphological interpolation. A geomorphological chart of the region was also compiled.

Investigations by the R/V M. Lomonossov and Academician Kovalevsky resulted in new data in various regions. Thus, on the slope of the southern Gulf of Mexico a complex structure was found. Within it a series of ranges, fractures, and bends were distinguished, caused evidently, by the submeridonal tectonic fault dislocation.

Rather detailed investigation of the Cayman Trench has resulted in a better knowledge of its morphology. The bottom of the trench is a chain of plain parts separated by cross-thresholds and longitudinal ranges. The maximum depth of the trench is 7,130 m. The Cayman Trench from the north has a well developed crest with minimum depths over it, which are considerably smaller than the ones indicated on charts.

Soundings in the Yucatan Basin demonstrated that its bottom is an accumulative, nearly subhorizontal plain on which gentle hills up to 150 m high, and sometimes larger ones with gentle slopes of elevation are met.

Naturally, the collected data which are available are not sufficient for the region. Therefore, it would be useful to compile all the existing material in order to plan the regions which should be studied in the first place, during 1970. On the basis of the International Expedition in 1970 bathymetric, geomorphological, morphometric and other special charts should be compiled.

No. 2.2

Sea-floor structure of the Eastern Greater Antilles

by

Louis E. Garrison
U.S. Geological Survey, Office of Marine Geology
Corpus Christi, Texas

and

Miner W. Buell, Jr.
U.S. Naval Oceanographic Office
Washington, D.C.

The structure of the Eastern Greater Antilles ridge is poorly known principally because it is largely covered by water. Recent seismic reflection profiling in the area, however, has shown some of

this submerged structure. The ridge is cut transversely by northwest-trending strike-slip faults, two of which are known to pass through Puerto Rico. South of the Antillean ridge the Muertos Trough marks the presence of a major strike-slip fault which is connected with the Cayman Fault zone. Another major strike-slip fault may form the south wall of the Puerto Rico Trench and pass eastward into the northern coast of Hispaniola. This suggests that the major structures of the Antillean ridge are tensional features created in the stressed region between the oppositely moving Atlantic and Caribbean crustal plates.

No. 2.3 Submarine canyons in front of the Cordillera de la Costa of Venezuela

by

J.M. Sellier de Civrieux
Instituto Oceanográfico
Universidad de Oriente
Cumaná

A bathymetric study of the topography of the Venezuelan continental shelf, between the Cordillera de la Costa and Bonaire Trench, was made using depth profiles from continuous echosounder observations. This survey revealed a system of submarine canyons located north of the western part of the Cordillera, between the Turiamo Bay and the Mamo River.

This section differs clearly from the adjacent areas: Golfo Triste towards the west and the eastern part of the shelf of the Cordillera to the east, having greater depth and more irregularity of bottom.

There is apparently a relationship between the submarine canyons and the drainage system of the northern side of the coastal Cordillera. The drainage on the part of the coast facing the shelf cut by the canyons is much better developed than in the two adjacent sections. The most important canyon corresponds to the mouth of the Mamo River (called Petaquire in its upper part) which is the longest and the largest river of the region. The second canyon in importance corresponds to the Ocumare River and its tributaries. Chuao and Choroni Rivers have less important canyons, partly covered with marine sediments.

The whole system of submarine canyons, including the Ocumare and Chuao, converge towards the Mamo Canyon, as if it were a drainage system. Mamo Canyon, with its submarine tributaries, empties in the Bonaire Trench, north of the area studied.

No. 2.4 Review of the geologic history of the Caribbean

by

H.J. Mac Gillavry
Geologisch Instituut der Universiteit Van Amsterdam

A review of the fragmentary and controversial information on Caribbean geology must mainly deal with areas above sea level. Information on the enclosed and surrounding sea floors is still largely geophysical.

The geological history of the Greater Antilles can be roughly divided into four phases which partly overlap each other and which are not simultaneous everywhere: a) a Cretaceous period of much volcanism and little or no supply of terrigenous detritus; b) a phase of Upper Cretaceous to Lower Paleogene foldings, serpentinite mobilization, quartz diorite intrusion, thrusting, and a limited amount of deposition of sediments of pronounced synorogenetic type, still accompanied by volcanic activity; c) a Tertiary phase of volcanic quiesence, of much subsidence and carbonate deposition, some folding, and considerable faulting; d) a younger Tertiary to recent phase marking the formation of present morphology, submarine topography, of the Cayman and Puerto Rico troughs, and of the present pattern of geophysical anomalies.

The history of the Leeward Islands is similar, but with less volcanic activity in the turbidite phase, and little carbonate deposition in the third phase.

The Windward Islands are a classical island arc: a volcanic inner arc and, in the northern half, a non-volcanic outer arc which, however, has a volcanic basal complex. Oldest dates of the inner arc are early Tertiary. Oldest rocks of the outer arc are quartz diorite pebbles in the Eocene of Saint Martin, and possibly the volcanic basal complex and quartz diorite intrusion of Désirade. Volcanic activity of the inner arc was continuous during the quiescent phase of the Greater Antilles, which accordingly cannot be explained by a quiescent episode of ocean floor spreading.

The enclosed Caribbean Sea - on a geophysical evidence dated by Eocene samples from the Beata Ridge - was stable at the same time that its margins were severely tectonised. Thus the islands can hardly have formed a straight north to south Cretaceous geosyncline, looped afterwards. Such stability, on a small scale, characterises the centre of Jamaica.

Whether sialic basement underlies the Cretaceous anywhere, depends on the age of several metamorphic complexes on the Greater Antilles. These may be masses of older rocks or alternatively Cretaceous tectonic blocks which suffered regional metamorphism and diaphthoresis. Oldest dated formations are the epimetamorphic Middle Jurassic deposits of the non-volcanic Pinar del Rio block; the detritus must have come from an eroding sialic land to the south of west Cuba. Upper Jurassic and Lower Cretaceous deep-water carbonate formations occur in the Pinar del Rio block and in northern central Cuba. Jurassic or Cretaceous evaporites occur under the cayos north of central Cuba and in the northern Guatemala. Still further outward is a belt of salt domes and submarine diapyrs.

Quartz diorites occur mainly in the Cretaceous volcanite piles and may have been formed out of this material. Serpentine outcrops are associated with thinner sedimentary cover, with thrust planes, and with faults of great vertical displacement. If allowance is made for subsequent thrusting, volcanics and quartz diorite appear in general to be located internally with regard to the enclosed Caribbean Sea, the serpentinite - at its first emplacement- externally; in Cuba, Hispaniola, and Venezuela this means: towards the flanking continents though separated from them by deeps.

The serpentinite belt of the Greater Antilles appears to connect with that of the American west coast through the serpentinite of the Paleozoic orogenic belt of central Guatemala, which serpentinite seems to have been remobilised after the Cretaceous. This may indicate a zone of mobility superseded now by the rift (tear zone?) of the Cayman and Puerto Rico troughs.

Tectonization does not seem to have led to much above-sea-level mountain building. Much of the thrusting may have been submarine and perhaps gravitational. Direction of movement was towards the north in Las Villas Province, Cuba; to the south in Curaçao, Paraguana, and the Venezuelan coast range.

In the Albian a family of rudists existed from Texas to Venezuela which evolved parallel to, but separate from the Eurasian fauna. In an early phase of the tectonic unrest, during the Barrettia biozone, an endemic fauna developed in a more restricted area (Greater Antilles to Chiapas). In the following Titanosarcolites biozone antillean type rudists migrated northward to Texas, perhaps even to Saskatchewan.

The geographic distribution of Mesozoic facies and fossils preclude Carey-like rearrangements of separate blocks. Geologic evidence of the Caribbean for or against theories of continental drift or ocean floor spreading is not clear.

No. 2.5

Distribution of the foraminifera of the emerged and submerged Holocene of the Cumaná region, Venezuela

by

J.M. Sellier de Civrieux
Instituto Oceanográfico
Universidad de Oriente
Cumaná

A comparative study between the recent foraminifera of the continental shelf of Cumaná, in the south-eastern slope of Cariaco Trench and the fossil foraminifera of the submerged Holocene in the adjacent coastal plains is made. Also, a study is presented on the foraminifera of the littoral lagoon of Patos and River Manzanares estuary.

The distribution and the qualitative composition of the submerged Holocene fauna in the coast, proves the existence and indicates the extension of subrecent lagoons on both sides of the present mouth of Manzanares River. These lagoons are now the coastal plains of Caigüire Abajo and San Luis. It is shown that the present Laguna de los Patos, in the south west of the plain of San Luis, is the last residue of the lagoons, the extension of which was much larger. The regression of the lagoons and the corresponding advance of the continent are attributed to the presence of fossil mangroves, which speeded up the rhythm of the alluvial and pluvial sedimentation from the estuary of Manzanares River and the erosion of the neighbouring hills. With these data a subrecent palaeographic map of the area is presented.

From the ecological point of view, faunistic provinces can be established, by the predominant genera and species and also by the relative percentages of different groups of foraminifera, particularly the relationship benthos-plankton. Such provinces are established not only for the continental shelf but also for the subrecent lagoons, the residual lagoon and the estuary. The relation between the faunistic provinces and the known ecological parameters are studied, comparing the present ecology and the subrecent palaeoecology of the area.

A short description of the faunistic composition of the different provinces is made, emphasizing in each case the genera and species of greater ecological significance.

No. 2.6

Recent sediments of the Caribbean and Adjacent Regions

by

W.D. Nesteroff
Laboratoire de Geologie Dynamique, Sorbonne

The recent sedimentation of the Caribbean and adjacent regions shallow waters is one of the most interesting in the world. On the one hand the coral reefs pose the problem of the age of their formation. Those of Florida for instance, date as far back as 5,000 years. On the other hand the carbonate formations, and particularly those of oolites, which cover the shelves and plateaux introduce the problem of the importance of physio-chemical precipitations, which is questioned by some authors.

The deposits in deep water are, on the contrary, rather traditional. The abyssal planes are filled with impurities, mainly of terrestrial origin. However, a thin layer of recent pelagic mud, reflecting the circulation of present superficial currents covers generally all these deep deposits.

No. 2.7

Mud on the oceanic shelf of Guyana

by

E. Allersma
Delft Hydraulics Laboratory

The Guyana coast stretches over 1,600 km between the mouths of the rivers Amazon and Orinoco. Its low swampy coastal plain and the adjacent shallow part (up to 30 metres depth) of the continental shelf consist of very fine sediments. This mud is not supplied by the local rivers but it originates from the Amazon River and is carried westward along the coast under the action of the Guyana current, the waves and the wind.

In fact, the coastal plain is a part of the delta of the Amazon river which has been gradually extended westward during recent Holocene times. The mud, which gives a brown colour to the 20 to 40 km wide belt of coastal waters, is an obstacle to navigation but it makes fertile land.

The rate of transport of mud along the coast is roughly estimated at 100 million tons per annum; being only a part of the sediment discharge of the Amazon River which is believed to be between 250 and 900 million tons annually. Ultimately the mud is deposited along the coast causing a gradual accretion of the coastal plain and compensating for a slow subsidence of the area.

More close observation reveals that a part of the mud moves along the coast in the form of huge wave-like shoals, each containing an average of 3,000 million cubic metres (1,500 million tons) of sediment. The "wave-length" of these mud-banks varies around 45 km and they shift westward at a speed of about 1.5 km a year. In this process large quantities of mud are eroded from the eastern flank of a shoal and deposted on its western slope.

The passing of these shoals causes a cyclic succession of periods of accretion and recession of the coast which can be inferred from successive hydrographic charts. For the same reason one observes a variation of the length and depth of the approaches to the rivers with a recurrence period of about 30 years.

Knowledge from observations in the Guyana area and from investigations elsewhere provide a general picture of the behaviour of the mud along this coast. The combination of a huge river discharging fine sediments and the oceanographic conditions of waves and currents prevailing in the area is rather unique in the world and, therefore, does not allow for comparison with other coasts in several important aspects. Little is still known about the mechanism by which the mud is transported. Much more information is needed about the magnitude, the variability and the interaction of many factors such as the waves and the swell, the flows, the winds, the properties of the water and the sediments, etc.

The unity of the coast and the phenomena as well as the comprehensiveness of the studies ask for cooperation of the adjacent countries and others involved in investigations in the area.

No. 2.8

Surface sediment facies of the continental margin off eastern Venezuela

by

Neil J. Maloney
Instituto Oceanográfico
Universidad de Oriente
Cumaná

The continental margin between Carupano and Cabo Codera, Venezuela (63° to 66° W long.) varies from borderland to terrace type bathymetry. East of Margarita the shelf is 80 to 100 km wide. Its inner, southern, region contains an east-sloping depression extending from a depth of 20 fath east of Margarita to more than 63 fath north of Trinidad. The northern border of the depression is formed by the bank passing from Cabo Codera to Margarita and on to Los Testigos Islands.

The depression is covered with olive-green silts containing 20% to 40% sand. Calcareous-shell, coralline and algal deposits occur on the bank. The outer shelf, north of the bank, varies from fine-grained to sandy sediments. Glauconitic sands are common suggesting the presence of relic sediments. The straights south of Margarita Island contain sands and gravels in the north and a mixture of sandy and muddy sediments in the south.

The continental borderland west of Margarita has a narrow shelf; the Cariaco Basin which is 192 km long, 32 km wide and 1,450 m deep; a submarine bank with a maximum sill depth of 140 m; and a continental slope complicated with submarine canyons, seamounts, and islands.

The shelf is less than 5 km wide west of Cumaná. It is covered with calcareous and terrigeneous sands to a depth of 100 fath where the sediment changes to an olive-green, clayey-silt containing less than 4% sand. The coast area east of Barcelona has a sediment distribution that is strongly influenced by the bathymetry. West of Barcelona, the shelf widens to a maximum of 40 km north of Unare River. The sandy sediments are restricted to the beach and dune areas; a large area of hard bottom is present at the shelf edge.

Dark grey to brown mud covers the Cariaco Basin. Calcareous sands cover much of the bank area north of the basin, and the continental slope contains dark grey, silty-clays and clayey-silts.

No. 2.9 Continental margin off central Venezuela

by

Neil J. Maloney
Instituto Oceanográfico
Universidad de Oriente
Cumaná

The continental margin between Aruba and Grenada is marked by the Bonaire Basin, the Cariaco Basin, and a continental terrace. The Bonaire Basin is 390 km long, 91 km wide, 2,050 m deep and has a sill depth of about 1,650 m. It has a continental shelf which is narrow or absent, but is marked by a plateau at 200 to 350 m. The outer margin of the basin is formed by the Aruba to Orchila island chain. Igneous and metamorphic rocks of Cretaceous or older age form the basement rocks on these islands. The island groups are separated by deep, structurally-controlled, submarine canyons, and four of the island groups contain bench areas at depths of 370 to 950 m. These benches may be related to the plateau on the south side of the basin.

The Cariaco Basin, to the east, is 192 km long, 32 km wide and 1,450 m deep. It is situated within the continental shelf and has a sill depth of only 140 m. Two submarine canyons are present on the basin slopes.

A continental shelf of erosional and sedimentary origin is present between Margarita and Trinidad. An east-trending valley-like feature occurs in the shelf. It is 35 km across, 210 km long and 55 to 115 m deep.

It is suggested that a series of west-trending right lateral (transform) faults originated on the continental margin as a result of the couple formed between west drifting continent and the east spreading Caribbean basin during continental drift. Basin development within the fault blocks appears to have migrated from west to east.

No. 2.10

Sediment distribution on the continental platform of northern north-eastern Brazil

by

Paulo Nóbrega Coutinho
Instituto Oceanográfico
Universidade Federal de Pernambuco
Recife, Pe

and

Jáder Onofre de Morais
Estação de Biologia Marinha
Universidade Federal do Ceará
Fortaleza, Ce

This paper is the result of a study on the sediments of the continental shelf of N-NE Brazil, sampled by the R/V Almirante Saldanha of the Brazilian Navy (cruise 35 - September-December 1967) and by the vessel Canopus of the SUDENE (June 1965 - February 1966).

Off the Territory of Amapá and the State of Pará the shelf is very wide. It may attain a width of 150 miles and has a gentle slope; the isobath of 20 m can occur even at a distance of 60 miles from the coast. In the State of Paraiba and Pernambuco the shelf becomes narrower, attaining a width of not more than 25 miles with a steeper slope. The submarine relief off Ceará and Rio Grande do Norte States is irregular due to volcanic phenomena. Of the State of Maranhão a "waving bottom" can be found in a NW direction. The whole coast is under the influence of the South Equatorial (Guyana) and Brazil currents.

Four sedimentary facies were distinguished:

1) Sandy littoral facies. This facies is under the influence of tides and other coastal phenomena. It is represented by sandy beaches, beach rock, local occurrences of mud, and biogenic accumulations of calcareous algae, corals and other organisms. Rounded to angular quartz grains with a vitreous to glossy surface character dominate, whereas pitted and frosted grains are more rare. Biogenic elements are present but never dominate. A poor microfauna shows Formainifera such as Archaias angulatus (Fichtel & Moll), Triloculina sp., Quinqueloculina sp. and Amphistegina radiata (Fichtel & Moll). The muddy areas show an accumulation of silty to clayey deposits between the reefs or near the mouths of small rivers. Among the Foraminifera, particularly of small size and with very thin tests, the families Miliolidae, Rotalidae and Bolivinidae can be found. The genera Ammonia beccarii (Linnaeus), Discorbis aff. parisiensis (d'Orbigny), Elphidium sp. are dominant. Kaolinite, illite and montmorillonite are the chief clay minerals. On the coast of northeastern Brazil sandstone reefs alongside the shore can be observed. They are composed of terrigenous sandy material cemented by calcium carbonate, originated as beach rock.

2) Organogenous facies. It is composed dominantly of fragments of organisms such as Foraminifera, bryozoans, ostracodes and, more rarely, pelecypods and gastropods, apart from other fragments not recognizable. Among the Foraminifera dominates the species Amphistegina radiata. This facies shows sandy to muddy sediments and its greatest extension occurs between the State of Piauí and the Amazon mouth.

3) Algal facies. Almost entirely composed of calcareous algae such as Lithothamnium Philippi, Lithophyllum Philippi and Halimeda Lamouroux, found as a mixture of pebble-sized ramificated and smaller fragments, being a very characteristic element of the investigated shelf. On the bottom also often occurs, aggregates of boulder size, beginnings of limestones. The Halimeda stems occur on the open shelf of northeastern Brazil suggesting that this area is rather quiet. The Foraminiferal microfauna is rich in Archaias angulatus, miliolids, Amphistegina radiata and textularids; planktonic Foraminifera occur rarely.

4) Mud facies. This facies occurs from the Marajó Island along the Amapá continental platform. The material is of terrigenous origin supplied by the Amazon River; it is almost without microfauna. Mud is also found as some isolated patches within the other parts of the shelf.

Mixtures of the organogenous facies with the surrounding ones are found in extensive areas where the shelf is wide.

It is suggested that the greater part of the organogenous and algal facies is relict, because of their occurrence and general aspect.

No. 2.11

The Paraguaná Peninsula; geology and natural resources

by

Gustavo Feo-Codecido
Compañía Shell de Venezuela, Ltd.
Caracas

This report describes briefly the most outstanding physiographic, stratigraphic, tectonic and economic aspects of the Paraguaná Peninsula, situated on the northern shore of the State of Falcón, Venezuela, and also discusses in a general way its geologic history.

The peninsula represents the northernmost outpost of the Venezuelan mainland in the Caribbean Sea and comprises an area of about 2,500 km^2, between the Gulfof Venezuela in the west and the Gulf of La Vela in the east. It is joined to the rest of Falcón by the Médanos Isthmus.

The predominant relief is made up of plains, which generally do not exceed 50 m above sea level; the highest altitude is at Cerro Santa Ana (815 m).

The oldest rock-stratigraphic unit exposed in the region consists of a series of quartz-feldspar and micaceous schists and gneisses injected by a body of granitic rocks of absolute age 262 to 265 m.y. This complex contains dyke rocks and belongs to a pre-Mesozoic basement.

Unconformably above is a sequence of semi-metamorphic mesozoic rocks of marine origin, about 1,400 m thick, composed mainly of slates, quartzites and limestones with very occasional ammonites. These rocks are cut by a system of acid dykes and appear to be intruded by a large mass of predominantly gabbroic rocks.

The above-mentioned rocks are overlain transgressively by a neritic sequence of marls, sandstones, clays and fossiliferous limestones of Mio-Pliocene age, reaching more than 1,200 m in thickness.

Quaternary alluvium deposits in the form of dunes, salt-and mud flats cover the coast and lowlands of the region.

Generally speaking, the structure of the peninsula is similar to a dome or wide arch whose flanks, composed of Mio-Pliocene sediments, dip gently away from a central igneous-metamorphic core.

In Pleistocene time Paraguaná was an island, but during the Holocene lost its insularity with the formation of the Médanos Isthmus.

Because of its situation on the continental shelf its waters constitute an important fish-breeding area. The raising of goats and sheep is also of economic importance to the region.

Its desert-type soil permits the cultivation of sesame seed (Sesamun indicun), which plays an important part in the agriculture economy of the State.

On the south flank of Cerro Rodeo there exists a chromite deposit associated with the exposed ultrabasic rocks; however, the small reserve (about 4,000 metric tons) does not justify exploitation. Large extensions of the coast contain salt-flats and in some inland areas fresh ground water is found in limited amounts; in this connection the Shell Foundation recently made an evaluation of the peninsula's ground water resources with the hope of improving the situation created by the water shortage in the region.

The two largest oil refineries in the country are located in Paraguaná; that is, Creole's at Amuay and Shell's at Cardón. In 1967, they refined 62% (41,919,000m^3 of oil) of the total processed in Venezuela.

No. 2.12

Research by the Atlantic Oceanographic Laboratory, Bedford Institute, in the Caribbean area during 1968

by

J.I. Marlowe, K.M. Kranck, and C.R. Mann
Atlantic Oceanographic Laboratories
Bedford Institute, Dartmouth, Nova Scotia

This paper summarizes investigations carried out by the Canadian scientific ship Hudson in the Caribbean in 1968. Operations lasted from February 6 to April 5, during which period scientific programmes were carried out by shipboard and shore-based parties. Nine programmes were undertaken covering geology, biology, and physical oceanography.

A brief resume of the work will be given. Preliminary geological results of trawls and cores collected in the Grenada Trough and on the Aves Ridge, and of sediment studies near the southern Grenadine Islands will be presented.

No. 2.13

Review of Geology and Geophysics of the Gulf of Mexico as it relates to the G.E.P. programme

by

Arnold H. Bouma and William R. Bryant
Texas A & M University, Department of Oceanography
College Station, Texas
and representing
Gulf Universities Research Corporation

The Gulf of Mexico is a basin with intermediate water depth. Refraction measurements show that the underlying crustal structure is more oceanic in character than continental. Its limited size and availability of geotechnical information from adjacent land areas (more than any other similar basin) make the Gulf an excellent laboratory for the study of marine structures, tectonics and sedimentation.

The Gulf should never be studied on its own but tied in with the Caribbean due to similarities in crustal structure to the Yucatan, Colombian and Venezuelan basins. The origins of these basins, as well as the Gulf, are closely related to the formation and development of island arc structures, well exemplified in the Caribbean.

The Geological and Geophysical section of the Department of Oceanography of Texas A & M University, as well as Lamont Geological Observatory, have contributed substantially to the description and interpretation of the shallow structures and the sediments in the Gulf of Mexico and Caribbean.

Two major petrographic provinces can be distinguished in the Gulf of Mexico. These meet at DeSoto and Campeche Canyons. The western part of the Gulf is a clastics province while the eastern part is predominantly carbonate.

The Florida Continental Shelf and Slope constitute a subsided (8000 feet since Lower Cretaceous) carbonate section. The Florida Scarp may represent a fault scarp concomitant with faulting and subsidence. DeSoto Canyon separates the Florida carbonates from the clastics province with its diapirically controlled structures of the Mississippi-Louisiana-Texas Continental Slope. Long east-west trending salt ridges with secondary growth in the form of salt stocks give rise to the hummocky topography of this region. The Sigsbee Scarp possibly represents the youngest and most seaward advance of this salt ridge system. The Mexican Continental Slope is characterized by a linear fold system, which trends approximately parallel to the trend of the shelf break. This fold zone is 150 miles wide and almost 400 miles long. The wave length of the folds is approximately 6 miles with an average relief of 1200 feet. Hypotheses for the origin of these features have included 1) sliding of sedimentary rocks on a decollement, 2) folding associated with compressional stress and 3) vertical movement of shale or salt masses, related to static loading.

The eastern wall of Campeche Canyon consists of an upbuilt carbonate continental terrace while its western wall contains a series of diapiric structures. The Campeche Shelf is typical of a constructional continental terrace including both upbuilding and outbuilding. This shelf is rimmed by a series of diapiric structures located on the southern Abyssal Plain and Mississippi Fan. The origin of these structures appears to be the upward migration of salt, which suggests that the major portion of the Gulf of Mexico is underlain by Louann salt.

No. 2.14

Geophysics of the Caribbean and adjacent areas: a synthesis of magnetic and seismic refraction results

by

Thomas W. Donnelly
Department of Geology, State University of New York

Although not entirely uniform throughout, the Caribbean and Gulf of Mexico crust is dominantly oceanic in character. Magnetic and seismic refraction surveys have proved to be most useful in delineating the distribution of various crustal types, but the identification of the crustal materials, and their inferred origins, remain debateable.

The four basin areas of the Caribbean-Gulf of Mexico region (Gulf of Mexico, Yucatan Basin, Colombian Basin, Venezuelan Basin), all have somewhat lower magnetic intensities than the adjacent western North Atlantic or eastern Pacific Ocean areas. Degrees of roughness or smoothness of magnetic profiles further differentiate among the individual basins. The Gulf of Mexico has very smooth magnetic profiles (except in the easternmost part), the Yucatan Basin shows equally smooth profiles, the Venezuelan Basin has smooth and rather rough areas and the Colombian Basin (as well as the adjacent Nicaragua Rise) is magnetically very rough.

Several of the more distinct individual anomalies can be correlated from track to track and hence, can be crudely mapped. These larger anomalies tend to be oriented principally east-west (especially in the western Caribbean) or northeast-southwest (especially in the Colombian and Venezuelan Basins). The more distinct individual anomalies appear to be of two types: those for which the solution would appear to require the presence of a strong component of remenant magnetization not parallel to the present earth's field direction, and those for which such a component is not required. The first type appears in most cases to indicate the presence of a subhorizontal component, which would be consistent with magnetization of a large igneous body during the late Paleozoic or early Mesozoic. These anomalies are located in the Yucatan Peninsula and adjacent seas, in the Yucatan Basin, and in western Haiti. Anomalies of the second type are especially conspicuous adjacent to the Cayman Trough and in the Colombian Basin.

Seismic refraction surveys of the four basin areas indicate varying similarities to typical oceanic crust. The Yucatan Basin has rather typical oceanic velocities, with the sediment layer slightly thicker than in Oceanic areas. The Gulf of Mexico is similar to the Yucatan Basin, except that the sediment (part of which may be lightly metamorphosed) is much thicker. The Colombian Basin is less easy to characterize: sediment thicknesses are great, and crustal and upper mantle velocities variable. The Venezuelan Basin has thinner sediment, and, especially in the eastern and northern parts, a conspicuously low-velocity crust and lower mantle.

Combining magnetic and seismic characteristics, we note that great sediment thicknesses and conspicuously low magnetic intensities (Gulf of Mexico, Colombian Basin) are related, and are apparently explained by depression of more susceptible material beneath a Curie isotherm surface as a result of sedimentation. The generally low magnetic intensities and lower crustal and upper mantle seismic velocities throughout the remainder of the Caribbean-Gulf of Mexico areas set these regions apart from the adjacent oceanic areas, and would appear to indicate a low-grade metamorphism of typically oceanic rocks.

General tectonic considerations are becoming more favourable towards a theory of origin of the Gulf of Mexico-Caribbean area resulting from continental rifting and drifting on a major scale, perhaps beginning in the later Paleozoic and continuing through much of the Mesozoic. The alignment of major magnetic anomalies, as well as other structures, is favourable to this idea. Most of the Caribbean and Gulf of Mexico crustal material could be oceanic crust of that age, though there is a possibility that some may be much older. The alternative explanation - that the crustal materials of the Caribbean, Gulf of Mexico, and adjacent oceanic areas are of about the same age, but that their various characteristics are best explained through the agency of different processes currently operating in these areas - has been considered, but is thought to be less probable.

No. 2.15 The gravity field of the southern Caribbean

by

R.A. Lagaay
Vening Meinesz Laboratory, University of Utrecht

An intepretation is given of the gravity anomalies in the area of the Netherlands Antilles: Aruba, Curaçao and Bonaire. The interpretation starts from a detailed gravity map of local isostatic anomalies which incorporates several new data. The investigated area forms part of the southern Caribbean anomaly zone.

The crustal structure, as interpreted from the gravity data, is best described as a wave-like deformation of the transitional crust between the Caribbean Sea and the South American continent. No crustal thickening is needed to explain the strip of negative gravity anomalies: the crust is down-warped below its equilibrium position and a secondary sedimentary layer of considerable thickness has been deposited. The crust in the positive strip has been raised above its equilibrium position.

It is suggested that a mechanism characterized by crustal displacements, accompanied by strike-slip faulting and combined with some overriding is responsible for the deformation.

The absence of crustal thickening in the zone of negative anomalies throws doubt upon the concept that the present negative zones represent an early stage of mountain building. Comparing the southern Caribbean zone with negative zones elsewhere in the Caribbean leads to suggestions as to their different origin.

No. 2.16 Petroleum prospecting in the Caribbean area

by

Daniel D. Arden, Jr.
Signal Exploration (Jamaica) Co., Kingston, Jamaica

In mid-1968 daily worldwide production of oil was estimated at 6,230,000 m^3 (39.2 million barrels). Approximately one-fifth of this production came from the Gulf of Mexico-Caribbean region, distributed among the Gulf Coast fields of the United States and Mexico and South American fields in Colombia, Venezuela, and Trinidad. Only an insignificant amount (1000 m^3/day) comes from the central part of this region, with 640 m^3/day from southern Florida, an estimated 360 m^3/day from Cuba, and as yet non-commercial oil in Barbados. Because exploration and development practices are well established in the producing areas of the Gulf Coast and South America and the primary objective of this Symposium is an examination of the undeveloped resources of the Caribbean, this review is directed at a survey of prospecting activities in the central, non-productive part of the region.

Interest in oil exploration in the Caribbean declined between 1959 and 1963. During the years subsequent to 1963, however, interest has been renewed, due in large part to three factors:

1) new legislation on the part of several countries to encourage outside investment;

2) improved exploration techniques, especially in offshore drilling and geophysical processes; and

3) evolution in geological ideas regarding the origin and history of the Caribbean and the effect on possible oil provinces.

A country-by-country review of all drilling and an analysis of geological and geophysical work and concession rights issued during the past five years reveals a progressive increase in activity. The Caribbean is on the threshold of a period of systematic investigation of its oil potential. Those countries with favourable geological conditions and a legal and economic climate which will encourage investment can anticipate sharing in this exploration effort. If substantial success is attained in any part of the area, the effort throughout the whole Caribbean will be further intensified.

Section III: Marine Biology

No. 3.1

Pelagic ecosystem in the area

by

R. Margalef
Instituto de Investigaciones Pesqueras, Barcelona

The euphotic layers of the American Mediterranean are subjected to a more or less developed complicated anticyclonic gyre, with descending water of low productivity in "centrally" located spots. Many peripheral areas show temporary upwelling for which determination, prevailing circulation, coastal wind and bottom topography are material. An opposite circulation close to the coasts is associated with the important rivers. The shifting boundaries between the peripheric fertile water and the more transparent oceanic one, are important as bearings in the concentration and movements of big pelagic animals. Nutrient enrichment of surface waters is important in the periphery, by mixing and upwelling; in the more central areas fertilization across the thermocline is more difficult and may be related to the proximity of islands and water circulation. Enrichment experiments and data on the ratio N/P show that nitrogen may be the most important limiting factor in offshore areas, and that P may limit productivity of coastal areas.

Estimates of phytoplankton biomass can be based only on plant pigments and on number and volume of cells. Existing data show cell numbers between 20 and 200 per ml, and allow carbon estimates of 0.7 to 5 g C/m^2. Differences between rich and poor areas appear somewhat damped because phytoplankton extends deeper and has a low turnover in poorer central areas. The 10% of maximum (subsurface) density is attained around 40 m depth in peripheric areas, but at more than 100 m depth in central areas. Plant pigments, transparency of water and diversity of net plankton are rapid and good indicators of general plankton properties. Below 20 m in coastal areas, a large proportion of pigments is detritic. Annual change in biomass amounts to 1:10, but somewhat less in offshore regions.

Primary production has been estimated by 14-C uptake. Where mechanism of fertilization are more effective, yearly net production exceeds 400 g C/m^2, and even 1000 g C/m^2 in bays and mangrove areas. In central, poor areas, yearly production is of the order of 20 to 100 g C/m^2. Yearly fluctuations in production are apparently of the same order as yearly fluctuations in phytoplankton biomass. In coastal waters of low transparency, production may be limited to the 20 m surface layer. Maxima may coincide with periods of stronger wind, or else with heavy rainfall. Information on periodicity, interannual differences, dissolved organic matter and role of bacteria is much needed.

There exists considerable information on distribution of copepods and other plankton animals, useful also for tracing the movements of the water masses, but we lack quantitative data on biomass, respiration and production. Technical problems are serious: nets allow ciliates to escape which are very important for their high turnover and as food for young fishes. Combined tentative estimates seem to indicate that zooplankton biomass may be of the same order as phytoplankton biomass, and even exceed it locally.

The distribution and abundance of larger animals reflects the same basic pattern as that of the phytoplankton. In coastal areas where influence of rivers, periodic upwelling and development of shelf are appropriate, populations of clupeoids (*Sardinella*, *Brevoordia*) are important and may attain a biomass of perhaps 3 g C/m^2.

Present day pelagic fisheries of the Caribbean and Gulf of Mexico represent an extraction of the order of 0.01 g C/m^2/year. This should be multiplied by 10 without going far from conventional methods. Future effort should concentrate on a more efficient and massive exploitation of clupeoids and other small fishes, that are efficient energy transformers.

No. 3.2

Distribution of plankton in relation to the general circulation system in the area of the Caribbean Sea and adjacent waters

by

Tagea K.S. Björnberg
Universidade de São Paulo
Dep. de Zoologia, São Paulo

Data on the general circulation in the Caribbean Sea and adjacent regions and qualitative, quantitative and biological information available on the different groups of plankton plants and animals studied in the area are summarized. Some bays and lagoons, and the Florida Current are amongst the best studied in the region. Larger and more thorough surveys of the plankton should be made in the whole area.

No. 3.3

Periodicity in the distribution of nutrients in the region of the Cariaco Trench

by

A. Ballester
Instituto de Investigaciones Pesqueras, Barcelona

The hydrographic and biological characteristics, to a great extent, depend upon the detailed situation within this region. Thus on the coastal shelf (in waters between the continent and the Islands of Margarita, Los Hermanos and Los Testigos, east of the Cariaco Trench) the temperatures and oxygen contents were always lower than in the region of the Cariaco Trench. The productivity was also always higher (in the region of 1 g C/m^2 per day) as was too the concentration of plant pigments (in the region of 1 mg of chlorophyll/m^3).

This high productivity is contributed to the supply of nutrient minerals from deeper waters. This again depends on the mechanism of upwelling which is more or less intensively developed in this zone.

In the Cariaco Trench (-1.390 m) the salinity is higher than on the continental shelf and the chlorophyll and primary productivity lower than those of the coastal waters. Its anaerobic character was described by M.L. Worthington in 1954 and is caused mainly by the high concentration of organic material originated from nearby areas of high productivity.

In the off-shore waters outside the slope, the productivity are lower than in the zones described above.

Special attention has been given to the values of the relation N/P which are both varied and in general very low. Richards and Vaccaro cite values between 3 and 4 for water depths between 50 m and the upper limit of the anaerobic zone. The study of the oxygen values with time show that the depth of the upper limit of the anaerobic zone in the Cariaco Trench varies during the year. In similarity with other hydrobiological and biological characteristics of this part of the Venezuelan Caribbean, this is related to the wind regime. In the periphic oceanic areas of this zone, the influence of the water from the River Orinoco is also very marked.

The strong periodic variations of the trade winds determine the seasonal cycle in the vertical transport which influences the hydrological and ecological characteristics of the region around the Cariaco Trench.

Since the euphotic zone of this region is intensively irradiated during the whole year, the photosynthesis results in a rapid depletion of nutrient salts; the efficiency of the vertical transport is demonstrated rather by the abundance and photosynthetic activity of the phytoplankton than by the concentrations of nutrient salts.

The measurements of primary productivity (by the C14 method) showed that with regard to the Cariaco Trench area and the continental shelf waters close by, there are two seasons of very different character which follow the periodicity of the hydrological regime.

No. 3.4

Distribution of nutrients on the north-eastern coast of Venezuela

by

Benito Rafael Gamboa
Instituto Oceanográfico
Universidad de Oriente
Cumaná

This paper tries to describe the distribution of nutrients in the north-eastern waters of Venezuela, from 10° 28' and 64° 46' and 13°N towards the coast, including the Paria Gulf, using data obtained from 1963 till December 1967.

The vertical and horizontal distribution of nutrients (nitrite, nitrate, ammonia and organic phosphorus) is studied taking into account the geographic and hydrographic conditions of this area.

No. 3.5

Productivity cycles off Jamaica and Barbados

by

D.M. Steven
Zoology Department
McGill University, Montreal

Except for areas of local upwelling the surface waters in the Caribbean are thermally stable, stratified and deficient in nutrients. There is little possibility of replenishment of the surface layers with nutrients from deeper water. Consequently primary production is generally low and relatively constant at all times and marked seasonal cycles, characteristic of higher latitudes, do not occur. However, more or less regularly recurring variations in production levels and related phenomena were observed in studies off Jamaica and Barbados from 1961 to 1964 and the causes of these are now being studied in greater detail. At Jamaica short-term peaks of primary production occurred in May and October separated by periods of relatively low production, while off Barbados primary production increased in the spring and was generally greater from May to September than at other times. The volume and dry weight of zooplankton off Jamaica rose and fell with a periodicity of two or three months and similar phenomena have been observed recently off Barbados.

The cause of these cyclical variations is not known at present. Off Jamaica the nitrite + nitrate-nitrogen concentration integrated from surface to 100 m also varied in a cyclical manner with a periodicity of two to four months and the peak concentration was generally out of phase with the peaks of phytoplankton numbers. Also, at one Jamaican station there was an inverse relation between net primary productivity and the numbers of herbivorous copepods. These observations suggest that the cyclical variations observed are all interralated and internally generated. An appropriate model for the behaviour of the components of the biological production system would be the interaction of a series of loosely coupled oscillators, the rhythm of the whole system being determined by a regularly recurring event, which could be synchronised breeding of one or more important zooplankters. Experiments are now being carried out in Barbados to test this hypothesis.

No. 3.6

Plankton studies in Campeche Bank

by

Alfredo de la Cruz S.
Centro de Investigaciones Pesqueras del Instituto Nacional de la Pesca
Playa Habana

This paper deals with a study of plankton from the Campeche Bank, north of the Yucátan Peninsula, where an important commercial fishery is in operation. Four cruises were made during the year and samples from the whole area at different levels were taken. The net used is quantitative and this provided the means to show the areas of major concentration, fluctuations and causal relationships. The total amount of plankton is calculated for the whole Bank and the most important organisms are

related and their abundance, distribution and seasonal variations studied. The data obtained were analysed in relation to oceanographic conditions and fishing.

No. 3.7 Results of Cuban-Soviet investigations on Campeche Bank area

by

Anatoli Elizarov, Nikolai Bessonov (Soviet Specialists)

and

Orestes González
Centro de Investigaciones Pesqueras del Instituto Nacional de la Pesca
Playa Habana

This paper deals with the results of the investigations carried out on Campeche Bank during the years 1962-1968 concerning oceanographic conditions, their causes and consequences.

Before 1962 the information of the main characteristics of this area were scarce and vague, but it was already known that the east area of the Bank was very productive owing to upwelling.

From 1962 to 1968 areas of upwelling were studied and it was found to be more intensive in summer than in winter.

In 1966 a more systematic study was made of the area for the purpose of locating more exactly the areas to be exploited, and to increase the knowledge of those already exploited, with special reference to the effect of the environment and its variations on fish.

Thanks to these studies we can conclude that the productivity of the Campeche Bank is determined by the cyclonic and anti-cyclonic circulations, dependent on the general movements of the currents on the Bank area, the movements of which are again determined by the Yucatan Current. The productive areas are thus limited in time and space. This paper also emphasizes the role of the water stratification on primary productivity and also the supersaturation of oxygen content, of phosphates and other elements.

The major concentration of benthonic fishes are related to the primary productivity of the areas in question.

No. 3.8 Phytoplankton distribution in the Caribbean region

by

E.J. Fergusson Wood
Institute of Marine Sciences, University of Miami, Florida

The phytoplankton of the Caribbean is essentially derived from the North Equatorial Current and appears to consist of two very similar communities, one in the surface water and one in the sub-tropical under-water. There are, however, a few species occurring in one and not in the other, and these appear through the water column only when mixing occurs. Neritic components are added along the coast of Brazil, Guiana and Venezuela and these appear in the sub-tropical under-water.

Benthic and epontic forms also appear in the sub-tropical under-water in the vicinity of shallow banks such as Gorda Bank and Arrowsmith Bank. The reasons these intrusions are at the 60 - 120 m. level is purely one of density as can be seen from the TS curves.

Another contribution is made from the Sargassum biocoenosis. The Sargassum itself probably makes a substantial contribution to the productivity of the Caribbean, and it also has a large epiphytic flora of diatoms including Synedra spp, Diploneis, Amphora etc. and these forms appear also in the plankton of the surface water.

It would be expected that the neritic contributions would be spread evenly through the waters of

the North Equatorial Currents as it approaches the West Indies, but it is not. It becomes separated rather widely and this can be related to the depth of the channels between the islands.

St. Lucia Channel, Anegada Passage, and Windward Passage are deep enough to allow the four water masses (surface, sub-tropical under-water, intermediate oxygen minimum and sub-Antarctic intermediate water, to enter the Caribbean without upwelling. In other channels, however, upwelling occurs and this causes lateral movement of the sub-tropical under-water, hence the diversion which can be detected by the spatial separation of the neritic components.

The phytoplankton maximum occurs in the sub-tropical under-water just above the salinity maximum, i.e. 60 to 120 m. and close to or below the 1% surface light level. After mixing, the phytoplankton maximum recurs at this level even in a mixed water.

This indicates the endemic nature of the maximum. The agreement of the phytoplankton picture with the hydrology of the area described by Wüst is remarkable.

For this paper I have chosen two profiles which are also given by Wüst, first along long. 75°W showing the effect of upwelling on the phytoplankton population, and second from St. Lucia Channel to Yucatan Channel.

Another interesting point is that the diatom Skeletonama costatum which blooms in the Amazon estuary and moves northwest with the North Equatorial Current remains in the sub-tropical under-water even when most cells of a chain are dead, i.e. there is in the ocean no evidence of the sinking of diatoms that is so often postulated by laboratory experimenters. Most of the sinking of phyto-plankton is due to downwelling of water masses and this has been traced in certain areas to a depth of 1,000 meters.

Our studies at Miami tend to strike an optimistic note in that we have evidence that the Caribbean is as productive as, or possibly more productive than the Antarctic over a 12 month period, and that productivity is probably much greater than that indicated by either oxygen or CO_2-assimilation measurements.

No. 3.9 Dinoflagellates and tintinnids of the Gulf of Mexico and Caribbean compared with the Equatorial Atlantic area

by

E. Balech
Museo Argentino de Ciencias Naturales B. Rivadavia
Necochea, Argentina

The author presents the results of microplanktonic observations (especially on dinoflagellates and tintinnids) of the Gulf of Mexico, supplemented with observations obtained during a cruise in the Caribbean and that of Equalant I in the equatorial West Atlantic region. As a result, the number of known species from the first two regions was considerably increased, including a certain number of new or little known genera or species. This is an indication of the poor knowledge of this region.

An analysis is made of the relations observed between the various cruises and their possible consequence in the areas of Panama City (Florida). In the second half of June 1964, an advance towards the coast of oceanic species was noted following the De Soto Canyon. In August these waters seemed to have been displaced towards the east. In September the number of species known as oceanic decreased, but in December they increased again in the whole area. In March there is a general increase of zooplankton and neritic forms even in relatively deep stations.

On the two cruises which comprise stations in the Yucatan region and northwards, in February 1965, deep water species were found on the surface which indicates a strong vertical mixing of the water.

The plankton of the Caribbean appear to be richer and more varied than that of the Gulf. Comparing it with the equatorial Atlantic we encounter marked similarities in its composition, above all in the relative abundance and presence of Histioneis, Heterodinium, Palaeophalacroma and Ensiculifera, as well as various tintinnids. There are greater differences when comparing the Caribbean and the Gulf. For example, Palaeophalacroma, common in the Atlantic and Caribbean, does not appear in any

sample from the Mexican Gulf. Similarly, the tintinnid, Codenella amphorella, is only found in the Gulf in two places close to the Yucatan Strait. Other species appear only in a few places in the Gulf. Most of these are also found in the Yucatan region, although some are occasionally found in other spots further north. In general terms, the plankton seem to indicate that the greater part of the water which enters the Strait of Yucatan makes a wide turn towards the east sending one branch towards the north, mainly following the 87° W Meridian, while another branch seems to make a turn towards the west and afterwards towards the east close to the coast. The plankton of these stations seems more closely related with that of the Yucatan than that of the central region. In the region of the Gulf most intensively studied, that of Panama City, there is evidence of important monthly fluctuations. In the section from the Yucatan Strait to Galveston, especially close to Yucatan, important vertical mixing was found. The need for a much longer study is stressed.

No. 3.10 Studies on the Zooplankton of the Caribbean Sea

by

Harding B. Owre and M. Foyo
Institute of Marine Science, University of Miami, Florida

The literature on the taxonomy and distribution of oceanic zooplankton in the Caribbean and adjacent waters consists in the main of works by H.B. Moore, H.B. Owre, M. Foyo and others in the Straits of Florida and by C.B. Wilson, J.H. Wickstead, A.G. Fish, H.B. Owre, and M. Foyo in the Caribbean.

The present research programme has been in progress since 1966 with the support of the U.S. National Science Foundation. Its objective is to relate the distribution and abundance of siphonophores, heteropods, pteropods, copepods, euphausiids, chaetognaths and salps to matching data on phytoplankton, temperature, salinity and depth in order to draw the general outlines of community structures in this large tropical sea.

Methods of sampling, especially below 2000 meters, were tested during an exploratory study made aboard R/V Pillsbury in January and February 1966. Zooplankton was collected at 17 stations in the Caribbean and off the Atlantic coast of South America. Since June 1966, extensive collections have been made in the Caribbean Sea with the intention of obtaining a complete series of samples spaced at intervals from surface to near the bottom. Where bottom depth is 3000 meters a typical series is made in two casts, the first with nets at surface, thermocline, 250, 500, 750, 1000 and 1500 meters, the second with nets at 2000, 2500 and 2800 meters.

Modified discovery nets attached to modified Niskin double-trip releasing mechanisms are opened at depth, fished for one hour and closed. Benthos Time-Depth Recorders attached to the mechanisms record events of the casts from beginning to end.

The complexity of studies necessary in such large series makes it premature to report results at this time. Previously made generalizations, such as the existence of a nursery area in the eastern Caribbean and the occurrence of greatest diversity of species in deep water and the largest populations of fewer species in the upper 100 meters, have been confirmed.

No. 3.11 Trapeze-like gear, a new system for rigging ichthyoplankton nets

by

D.J. Guitart Manday
Instituto de Oceanología, La Habana

A mid-water net is described which enables the capture of more and larger sized larvae and juvenile fish than any other conventional equipment.

This system was considered at the FAO Expert Meeting on Tuna Fish Research which took place in Tokyo, 1966 (FAO Fisheries Report No. 37, 1966).

Satisfactory testings were made with a 1 meter diameter net, with a nylon mesh of 0.5 mm, at a depth of 0-2, 25 and 50 meters. The system could be adapted to closing nets.

No. 3.12 Distribution of the marine benthic flora of the Caribbean Sea

M. Díaz-Piferrer
Industrial Research Department, Puerto Rico Development Administration
and Department of Biology, University of Puerto Rico

The history of phycological research in the Caribbean has been summarized by W.R. Taylor with descriptions of taxa and substantial knowledge of the marine flora of tropical and sub-tropical Western Atlantic. Also numerous papers from American, European and Latin American phycologists have contributed to the knowledge of our flora for the last decade.

The geographical area covered by this research extends from Bermuda, North Carolina, Florida, Caribbean to Brazil and Argentina. According to reliable sources, the western tropical and sub-tropical Atlantic marine flora is typified by what appears in the Caribbean. The northward extension of this flora is favoured by the Gulf Stream system. This type of algal vegetation does not show striking differences going south across the Equator and appears to retain the essential characteristics far toward the southern boundary of Brazil. Influenced by the southerly Brazilian Current the same type of flora extends south to Uruguay and Argentina where new elements dominate.

From 827 species, 130 (15.7%) are restricted to the Caribbean; 205 species (24.8%) range from the Caribbean northward to Florida, Bermuda or North Carolina; 56 species (6.7%) range southward to Brazil or farther south; 282 species (34.1%) are known from localities over the entire range. Excluding the Cyanophyta, 673 species are present in the Caribbean which is 81% of the total of known species. It is evident that an increasing number of species are extending their range from the Caribbean northward and southward, and vice versa.

51 species are recorded below a depth of 15 meters, 32 of them are denizens of the Caribbean. Genera inhabiting cold seas have been reported from deep waters in the tropics. The Brazilian phycologists reported Laminaria, with two new species, in about 70 meters of depth off Eastern Brazil. Díaz-Piferrer reports Desmarestia aculeata, Desmarestia ligulata, Hymenena media and Antithamnion plumula from Sonda de Vieques, off north-east Puerto Rico, dredged from 50 to 70 m deep. Dredging during the Phycological Expedition to Venezuela in 1966, provided extensions of range of numerous species only known from the northern or southern boundaries of our flora. Deep water research must be supported for the extensive exploration of the marine flora of tropical and sub-tropical Atlantic.

Regarding the seaweed of economical importance, the following groups are dwellers of the Caribbean: Chlorophyta with 6 genera and 16 species; Phaeophyta with 7 genera and 22 species; Rhodophyta with 22 genera and 56 species. These plants could be useful to obtain flours of high nutritional values, alginates, agoroids and medical substances. Nevertheless, research should be conducted to establish clearly the usefulness of such species and, at the same time, we must encourage research on the culturing of these species because MARICULTURE is the only answer for the use of seaweeds as a source of raw material for industrial purposes.

No. 3.13 A comparison of the Phytobenthos flora between The Caribbean and Mediterranean Seas

by

Lieselotte Hammer
Institut für Meereskunde, Kiel

In the present context an attempt is made to summarize the general data on the benthal flora of the Mediterranean and the Caribbean Seas. One of the most significant ecological factors is found to be the annual temperature variation. Due to this, seasonal changes in algal successions occur in the Mediterrean, whereas the periodic changes of benthic algae in tropical littorals are shown to be caused by the extent of wave movements. Also the tolerance of low temperatures of tropical algae plays an important role and is the reason why many tropical species occur also in the Mediterranean. The differences in the composition of the species in both littoral regions are discussed. It is shown that the R/P Quotient (Feldmann) is 2,6 in the Mediterranean and 4-5 in the Caribbean. Moreover, the rate of endemic species in both regions gives a characteristic picture: only few endemic species are found in the Mediterranean, whereas about 28% of all recorded species of the Caribbean are endemic. In total, approximately 790 species are known from the Caribbean, whereas from the

Mediterranean 500-600 species are described. The vertical distribution of the algae follows in the Mediterranean the normal scheme, as it is: green, brown, red; in opposition to this, we find in the Caribbean the green algae prevailing in the depth.

Considering the submerged marine vascular plants, none of the species is common to both areas. The vertical limit is, with one exception, the depth of 10-12 m (Max. 15m); this may be caused by the hydrostatic pressure. In both places, the phanerogams carry a very abundant and rich flora of epiphytic algae (uni - and pluricellular).

No. 3.14

The female gametophyte of Dohrniella antillarium var. brasiliensis

by

A.B. Joly and E.C. de Oliveira Filho
Universidade de São Paulo
Dep. de Botanica, São Paulo

This paper describes for the first time the female gametophyte of Dohrniella antillarum (Taylor) Feldmann-Mazoyer var. brasiliensis Joly et Ugadim.

As is known Dohrniella Funk 1922 and Callithamniella Feldmann-Mazoyer 1938 are the only genera belonging to the tribe Dohrnielleae Feldmann-Mazoyer 1940, of the Ceramiaceae. Recently (L'Hardy-Halos 1966) the sexual phase of Dohrniella neapolitan Funk, was described for the first time, the only other species of the genus. The present findings give evidence in support of the maintenance of the American species in this genus and are in general agreement with the female structures reported by L'Hardy-Halos.

The carpogonial branch - the female structure - is borne from a fertile pericentral cut off by the upper intercalary - cells of the main axis. It has as usual, four cells, placed on a straight line, lying parallel to the main axis. The cystocarp is formed by four, roundish gonimolobes, the two upper ones being larger than the two inferior ones.

No. 3.15

Reproduction in the brown alga, Zonaria farlowii

by

Larry B. Liddle
Department of Biology
University of Puerto Rico, Rio Piedras

Zonaria farlowii is a member of the brown algal order, the Dictyotales, which is primarily tropical in distribution. Interest in the Dictyotales is attributed to the distinctive life cycle which is categorized as an alternation of isomorphic generations. There are three plants in the life cycle, all of which display identical vegetative morphology. The development of these plants is, however, from different origins. In Zonaria farlowii, as in most other Dictyotales, the male, female, and asexual plants are distinguished by the appearance of the clusters of reproductive cells, the sori. These superficial sori are easily observed in the field, under the dissecting microscope, and they are easily manipulated for light and electron microscopic studies. The sori release their reproductive cells into the water at regular intervals. The large egg (100 μ) is fertilized by the uniflagellate sperm and the resultant zygote develops into a diploid asexual plant. The asexual spores are produced by meiosis and after release develop into both male and female plants. Release of the sexual reproductive cells is precise and periodic, occurring monthly. The release of the asexual reproductive cells does not follow this periodicity. With these qualities to recommend Zonaria farlowii, this organism was found to be an excellent system in which to compare oogenesis and sporogenesis and for the study of development.

Plants were observed for release of reproductive cells for one year. The lunar periodicity of egg and sperm release was established. The rate of development of the oogonium and sporangium was established by regular sampling of a clone of developing plants. Oogonia and sporangia were centrifuged on the plant in order to separate out the cellular contents of each to determine

quantitative cytological differences and similarities between the two reproductive cells. At the same time uncentrifuged and centrifuged oogonia and sporangia were fixed for the electron microscope. It has been found that the oogonium and sporangium differ in the amount of oil produced during their development.

There is a distinctive double-band of plastids always present after the third week of development in the oogonium and this pattern persists until the egg is fertilized, after which the zygote has the appearance of the asexual spore in which the plastids are arranged centrally around the nucleus. It was found that an optimum size must be attained by the functional reproductive cells. The sporangium which produces eight spores has a volume only slightly larger at maturity than the oogonium which produces one egg, yet these two reproductive cells have approximately the same size when released. These data provide some unique insights into plant development.

No. 3.16

Calcification in the calcareous alga Halimeda opuntia (L) (Chlorophyta, Udoteaceae)

by

E.L. Böhm
Biochemistry Department and Coral Reef Project
University of the West Indies, Mona, Kingston

Tracer studies are described which revealed that the uptake of Ca^{++} from the seawater and the deposition of $CaCO_3$ by the calcareous alga Halimeda opuntia occurs concomitantly with the remobilization of Ca from the mineral skeleton and the release of Ca^{++} into the seawater. The rate of Ca uptake is approximately 400 µg Ca/g alga/min. and exceeds the rate of Ca release by a factor of 1.007. The rate of total Ca turnover is about 800 µg Ca/g alga/min. whereas the rate of Ca net turnover, i.e. the rate of Ca accretion into the skeleton is only between 3 and 4 µg Ca/g alga/min. The Ca exchange system seawater-alga appears to contain more than two compartments and there is substantial evidence that Ca complexed to water soluble polysaccharides may be one of them. Models for pathways of Ca are suggested and discussed.

No. 3.17

Distribution of the benthic macrofauna and its relationship with some physical and chemical characteristics of the sediments of the Cariaco Gulf

by

Miguel López López
Instituto Oceanográfico
Universidad de Oriente
Cumaná

The Cariaco Gulf on the north-east coast of Venezuela is an area of great fishing productivity. With the aim of studying some of the physical and chemical characteristics of the bottom, a trip was made from 28 February to 4 March 1968. Forty-six stations were planned but only forty-three could be worked. On the basis of the samples obtained analyses were made for C, organic nitrogen, S, oxygen and granulometry. Besides, samples of the benthos were taken.

The results show peculiar characteristics for the central part of the Gulf. The figures for organic matter and oxygen consumption were higher and the benthonic populations lower than in the rest of the area.

In general, the S content was low.

No. 3.18

Nordic marine biological investigations in the Bahamas and in Florida

by

Hans Brattström
Biological Station, University of Bergen

Since 1960 Nordic marine biologists have carried out research at the Institute of Marine Sciences in Miami or have participated in the "Survey of the Bahamas", carried out by the Lerner Marine Laboratory at Bimini.

Most studies centred on ecological problems, but as detailed knowledge of the species is a prerequisite for ecological research it was deemed necessary first to learn the fauna and flora and to describe any new species. Thus taxonomic investigations have predominated so far, mainly on Foraminifera, Entoprocta, Copepoda, Ascothoracica, Mysidacea, Cumacea, non-parasitic Isopoda, Anomura, Gastropoda, Bryozoa, Pogonophora, and Algae.

Only part of the collections have yet been worked up. A very large number of species are new to the area and to the western Atlantic. In some groups even 50 to 100% of the species found were new to science. The reason for this is that most of them belong to the epibenthos. This element, often overlooked because it cannot be caught by standard sampling techniques, was successfully collected with the Beyer and Ockelmann sledges. The epibenthic animals were very abundant in shallow water and probably play an important role in the food chains of the sea.

The ecology of species belonging to most of the groups mentioned has been investigated and rocky shore zonation was one of the main topics during the Bahama cruises. The preliminary results show a zonation pattern of the universal type with a sub-division of the littoral zone into three main belts. The number of rock-boring forms and animals living in crevices is high. The Anomura, Mollusca, and Algae were the object of special investigations and an association between a chiton and two species of Isopoda was discovered.

Plankton was collected to obtain pelagic members of the groups of which bottom-living species were also collected and in order to study the succession through the night of species caught by using light.

An extensive study of the morphology, development, locomotion and food uptake in pelagic larvae of most invertebrate phyla was made in order to solve basic problems concerning their life cycle and its evolution. Embryological studies have also been made on isopods, molluscs, and entoprocts. In the Entoprocta a new type of development was discovered.

Extensive material collected in Florida was used for a histological study of the nauplius eye and frontal organs in Crustacea and of the photophores in Euphausiacea.

No. 3.19

Biological investigations off the east coast of Jamaica

by

I.M. Goodbody and J.L. Munro
University of the West Indies
Mona, Kingston

The pelagic and planktonic organisms and their physical environment in the surface and mid-waters off the east coast of Jamaica are described on the basis of step-oblique plankton tows, mid-water trawling, and determination of chlorophyll concentrations, temperature profiles and salinity.

No. 3.20 The mesobenthic fauna of the Jamaica Rise

by

J.L. Munro and I.M. Goodbody
University of the West Indies
Mona, Kingston

The benthic animals at depths of 550-1350 m on the Jamaica Rise off the south coast of Jamaica were sampled using a two metre frame trawl. The species and number of animals captured at various depths are listed and the stomach contents of some elements of the fauna are commented upon.

No. 3.21 Recent Colombian progress in the field of marine biology

by

Luis Ortíz Borda
Universidad de Bogotá
Jorge Tadeo Lozano, Bogotá

For many years Colombia did not investigate its marine resources but now, after seven years of work in the Faculty of Marine Sciences, our country is able to undertake studies of oceanography.

Studies on oceanography began in 1962. A cooperation programme was developed in order to send 48 students to foreign countries. Twenty-one of them returned to Colombia in 1968.

Colombia has two Marine Sciences Laboratories, both of them located on the Caribbean Coast. The Justus Liebig University of Giessen operates one of them in Santa Marta (Magdalena) and the other is under direction of Inderena. It is situated in Cartagena (Bolivar).

By agreement between the Colombian Navy and the Faculty of Marine Sciences (Universidad de Bogotá Jorge Tadeo Lozano) it was possible to build the Oceanographic Naval Institute.

Two new projects are going to be developed for building laboratories on the Pacific Coast.

The National Navy has designated three ships for oceanographic studies: two of them are the Quindío and the Gorgona, the other is a 300 foot APD for oceanographic research.

The Marine Fishing Development project will receive a boat in February or March 1969 and this will be used for exploratory fishing. Its length is 107 feet and it has an action radius of 15 days.

Taxonomic and Biological research is performed along the coasts and as a result the collection of the University of Bogotá "Marine Museum" will be greatly enriched.

No. 3.22 Ecological studies on a coral reef at Veracruz, México

by

Alejandro Villalobos Figueroa
Universidad Naciónal Autonoma de México

Research workers of the Instituto de Biología are studying the reef complex off the Port of Veracruz. They have focussed on the "La Blanquilla" reef of this system (19°13'35" N, 96°06' W) to define the faunal components of the communities and establish the characteristics of their distribution in accordance with the abiotic factors of the locality. The hydrography of the surrounding waters is influenced by waters of oceanic origin. The structure of the benthic faunal communities is related to that water mass. The composition of the madreporarians is being studied and they are mentioned at a new locality off Veracruz. The most conspicuous species of sponges and alcyonarians at the site mentioned were identified for the first time.

The discovery of two species of echinoderm is mentioned: a crinoid whose typical location is "La Blanquilla" and a species of gorgonocephalic ophiurid different from another know species, Astrocaneum herrerai from Yucatán. The capture of Antennarius tenebrosus in the western area of the reef is reported and the significance of its presence among the reef fauna is commented upon.

No. 3.23 Studies on the morphology, anatomy, reproduction and taxonomy of some Caribbean crustose corallinaceae

by

E.K. Ganesan
Instituto Oceanográfico
Universidad de Oriente
Cumaná

Details of morphology, anatomy and reproduction are described in Fosliella farinosa (Lamx.) Howe based on collections from eastern Venezuela. Of particular interest is that hair-bearing cells (trichocytes) may also be absent in this species. Based on the difference in vegetative structure i.e. F. farinosa with a monostromatic sterile thallus and F. lejolisii with polystomatic (2-4 layered) sterile thallus, the author considers these two as separate species.

No. 3.24 Deep-water fish of the Caribbean Sea and the Gulf of Mexico

by

T.S. Rass
Institute of Oceanography of the Academy of Sciences
of the U.S.S.R., Moscow

The American Mediterranean region is defined as the Gulf of Mexico and the Caribbean Sea, and is extremely rich in abyssal fish species.

Though separated from the Atlantic by chains of islands and submarine ridges, its water masses are greatly influenced by the western equatorial currents and are well oxygenated (5-6 ml/l at a depth of 2,500 m). Conditions of life are very different from those in the European Mediterranean Sea, which is more isolated from the Atlantic. The abyssal ichthyofauna is comparable to that in the Gulf of Guinea, which is fully open to the ocean.

At these depths there are about 275 species: 203 in the Gulf of Mexico, 160 in the Caribbean and 88 common to both basins. Thirty percent of this ichthyofauna occurs in ratios similar to those of the same species to the total number of species in the Gulf of Guinea, and almost double the ratio in the European Mediterranean.

Of the 62 teleost families, 13 predominate, accounting for 80 percent of all abyssal species. These are represented by the following groups: Stomiatidae (60 species), Myctophidae (34), Gadidae (28), Gonostomatidae (27), Ceratiidae (19), Brotulidae (17), Alepocephalidae (16), Alepisauridae (13) and Berycidae (12). The American Mediterranean region is characterized by a distinctive abundance of bathypelagic Melanostomiatidae (40 species, 37 percent) and Ceratiidae (19, 20 percent). Next in order are the families of the Alepocephalidae (14 species) and Brotulidae (15). Only 8 species of Melanostomiatidae, 13 of Ceratiidae, four of Alepocephalidae and four of Brotulidae are known in Guinea and, in the European Mediterranean, 1, 1, 2 and 3 species, respectively. However, there are fewer oceanic mesopelagic species of Myctophidae and benthic Macrouridae in the American Mediterranean than in Guinea (23 and 20 American species and 45 and 48 in the Gulf of Guinea respectively), but they are more numerous than in the European Mediterranean (15 and 6 species, respectively). The number of bathypelagic and mesopelagic Gonostomatidae (19 species), Paralepididae (10) and Melamphaidae (7) in the American Mediterranean is smaller than in the Gulf of Guinea (20, 13 and 10 species, respectively) but larger than in the European Mediterranean Sea, which has 7 species of Gonostomatidae, 6 of Paralepididae, and none of Melamphaidae. There is a considerable difference between the Caribbean Sea and the Gulf of Mexico in the composition of their abyssal ichthyofauna. The former has more species of Melanostomiatidae (37) and Ceratiidae (18) than the Gulf of Mexico (11 and 4 species, respectively), and most of the latter are also represented in the Caribbean Sea

(8 of 11 species and 3 of 4, respectively). The proportions are reversed in the families of the Alepocephalidea, Gonostomatidae, Myctophidae, Macrouridae and Brotulidae. The Caribbean Sea is apparently poorer in these groups than the Gulf of Mexico. The American Mediterranean region appears to be a centre for Melanostomiatidae species differentiation. That of the Ceratiidae is probably located near the Caribbean region, in the Bay of Panama.

Further research may probably add to what is known about the zoogeography of the abyssal waters of the ocean.

No. 3.25 Zoogeography of the deep-sea fish genus Bathypterois in the western Atlantic

by

Harvey R. Bullis, Jr. and Luis R. Rivas
Bureau of Commercial Fisheries, Exploratory Fishing and Gear Research Base,
Pascagoula, Mississippi

This study is an attempt to correlate the abundance and distribution of four species of Bathypterois with ecological and geographical factors. About 96% of the material was collected by Bureau of Commercial Fisheries exploratory vessels. Each species occupies a different depth stratum on the Continental Slope and upper abyss. Depth distribution ranges from 275 to 965 fathoms and temperatures of occurrence from 41 to 52° Fahrenheit. It is noted that all four species show different depth preferences between the Gulf and Caribbean populations. A distributional map is given in addition to tables and figures summarizing the data discussed in the text.

No. 3.26 A new research centre in Santa Marta, Colombia

by

R. Kaufmann
Colombia

In 1963 an association was formed between the University of Giessen, Germany, and the Universidad de los Andes, Bogotá (Colombia), following which the organization of a new centre for research was started in 1964 on the Atlantic coast of Colombia. The Colombian-German Institute is associated with the Institute of Tropical Research of the University of Giessen and it offers, in spite of its small number of permanent personnel, working facilities for visiting scientists in the fields of marine biology, oceanography, zoology, botany, geography and geology. Its favourable location makes the Institute an appropriate centre for scientific exploration of the southern region of the Caribbean Sea and of northern Colombia.

No. 3.27 Contributions to the bibliography on marine science of the Southern Caribbean; marine biology and fisheries

by

Domingo González and Germán González
Instituto Oceanográfico, Universidad de Oriente
Cumaná

This bibliography is a contribution to the present knowledge of publications on: marine biology and fisheries in the Southern Caribbean between Cape Gracias a Dios (Nicaragua), lat 15° 00' N, long 83° 10' W, and Cape Orange (Brazil), lat 4° 25' N and long 51° 32' W.

It deals with approximately 700 bibliographic references on the following topics: marine mammals, marine birds and reptiles, fishes, marine flora, marine invertebrates, zoo- and phytoplankton. A general analysis of the present state of knowledge on marine biology and fisheries in the Southern Caribbean follows, and a systematic subject matter index is included.

No. 3.28 Need for thorough inventory of tropical American marine biotas before completion of inter-oceanic sealevel canal

by

Carl L. Hubbs
Scripps Institution of Oceanography
La Jolla, California

Impending construction across the inter-American isthmus of a sealevel, seawater inter-oceanic canal presents most urgent need, and vast opportunity, for systematic, ecological, and evolutionary research. This canal will induce very extensive interchange between tropical Atlantic and Pacific marine faunas and floras that were united until late Cenozoic time but have been separated for more than a million years. The resulting speciation provides a measure of rate of evolution, but material for this determination must be obtained before the biotic interchange. The bringing together of many geminate species will furnish an unmatched opportunity to study evolutionary effects of their expected extensive hybridization, and to analyze the dispersals, establishments, competition, replacement, and other interactions of deep ecological and evolutionary significance. Vast natural experiments will provide prime opportunity for basic research. But the chance will be lost - at least blurred - unless the basic inventory is adequate.

The most urgent need is to amass, with full data, large collections representing the present biotas, for prompt research if feasible, but for later analysis if necessary. The whole mass of biogeographical data involved is jeopardized.

The Suez Canal provides an imperfect model to estimate the biotic consequences of the American sea-level canal. Passage through the model was long inhibited by the hypersaline Bitter Lakes and by the long route. Movement has been almost entirely into the Mediterranean, whereas passage through the American canal will almost surely be reciprocal. The vastly longer separation of the Indo-Pacific Red Sea and the Mediterranean biotas has provided little opportunity for evolutionary and ecological studies.

Biotic transfers through the American canal may have vast but not precisely predictable economic effects, for better or worse. Recreationally and economically important species may become established on the opposite side of the isthmus. Tarpon will likely become numerous on the Pacific side, to assume great recreational value in lagoons of Central America. Fishes, shrimps, and molluscs may pass through the canal to provide commercial fisheries in the opposite ocean.

Some transfers may be harmful or disastrous. Fear has been aroused that the highly venemous sea-snake of the Pacific may disperse into the Atlantic to create apprehension on swimming beaches in Florida and Brazil. Introduced species may displace superior native forms. Hybridization may produce sterile offspring. Parasites, bacteria, and viruses may disastrously infest non-resistant hosts. To estimate whether deleterious effects will offset beneficial ones will call for adequate inventory.

The initial inventory will need be conducted and the subsequent events will need be followed from Gulf of Mexico to Brazil and from Gulf of California to Perú, and will need to involve deep-water and pelagic biotas.

The problems raised by the impending sealevel canal are so urgent, are of such great scientific interest and economic concern, and are so definitely international, as to call for extensive consideration and action by Unesco, in the International Biological Program, and in other international as well as national activities.

No. 3.29

A revision of Zoogeographical regions in the warm water area of the Western Atlantic

by

George C. Miller
Bureau of Commercial Fisheries, U.S.A.

Zoogeographical regions in the warm water area of the Western Atlantic are revised on the basis of distributions of shelf, slope, pelagic, and insular marine organisms. The warm water area consists of three regions: Northern Warm-Temperate, Southern Warm-Temperate, and Tropical. There is no Subtropical region.

The Warm-Temperate regions are distinguished by water temperature inversions in the inshore area during the fall, winter and spring caused by periodic atmospheric cold fronts; by warm surface currents derived from the South Equatorial Current; and by one border defined by a convergence of warm and cold currents and the other border by the Tropical region.

The Northern Warm-Temperate region extends from Cape Hatteras, North Carolina, to Miami, Florida, and from Florida Bay, near Cape Sable through the northern Gulf of Mexico to Tampico, Mexico. Transitional zones in which warm temperate species decrease southward and species with subtropical tolerances decrease northward, exist in Florida from Pensacola to Florida Bay, and from Jacksonville to Miami, and in the western Gulf of Mexico from the Mexican border to Tampico. A subtropical zone on the shelf deeper than 15 fathoms supports communities which are able to live in subtropical temperatures.

The Southern Warm-Temperate region extends from Rio de Janeiro to the Rio de la Plata delta and is the least known biologically.

The Tropical region is distinguished by live coral reefs at or very near the surface. The Tropical region consists of three subregions: Northern Cool-Tropical; Warm Tropical or Antillean; and Southern Cool-Tropical.

The Northern Cool-Tropical subregion extends from Miami south through the Florida Keys to and including the Dry Tortugas, and in the southern Gulf of Mexico from Campeche Bank to Tampico. The warm surface currents are derived from the South Equatorial Current. Upwelling on Campeche Bank in late spring and summer permits some temperate species to live there and excludes some tropical species.

The Warm-Tropical or Antillean subregion is the hot equatorial area of the western Atlantic. This subregion includes the Bahamas, Greater and Lesser Antilles, and northwestern Caribbean south to Guatemala and east to Jamaica. Transistional zones between the Warm-Tropical and Southern Cool-Tropical subregions occur from British Honduras to Jamaica and in the islands from Curaçao to Barbados. The very warm surface currents of the Antilles (derived from the North Equatorial Current) and the Honduran eddy region help to distinguish the Warm-Tropical subregion. Bathymetric submergence of species occurs towards the Warm-Tropical subregion. The Warm-Tropical subregion is distinctive; it harbours endemic species, causes disjunct Anti-Antillean distributions, and separates cognate species.

The Southern Cool-Tropical subregion extends from British Honduras south to Rio de Janeiro, Brazil. Its warm surface currents are derived from the South Equatorial Current. The Southern Cool-Tropical subregion is considerably richer in species than the Northern Cool-Tropical subregion. Temperature and currents, not bottom habitat, are the primary factors in limiting the northernmost distribution of species from the Southern Cool-Tropical subregion.

Section IV: Fishery Resources

No. 4.1 Tunas and tuna fisheries of the Caribbean region

by

John P. Wise and Albert C. Jones
Bureau of Commercial Fisheries, U.S.A.

Total annual landings of tunas from the Caribbean region are estimated at about 29 thousand metric tons per year. Most tunas are taken by the longline fisheries, based on the yellowfin and other large tunas. The surface fisheries, based on skipjack, blackfin, and other small tunas, are secondary in overall importance but of primary interest to the Caribbean countries and territories. Prospects for enlargement of the longline fishery are not promising (there is evidence of overfishing), but there is no doubt that local surface fisheries for local consumption and possibly for modest exports can be developed in many Caribbean areas.

No. 4.2 Dynamics of the yellowfin tuna fishery of the Caribbean region

by

John P. Wise and William W. Fox, Jr.
Bureau of Commercial Fisheries, U.S.A.

The most important species in the longline fishery in the Caribben region is the yellowfin tuna, making up some 60% of the catch. Continued fishing at the 1964-65 level, about 20 million hooks annually, should cause catches to decrease markedly before stabilizing. Maximum sustained yield should be obtained with a fishing effort of about 10 million hooks per year.

No. 4.3 Population structure of the yellowfin tuna

by

Misao Honma and Koichi Hisada
Far Seas Fisheries Research Laboratory, Shimizu

The detailed catch records of the Japanese tuna longline fleet were utilized in this study.

The distribution of hooking rate of the yellowfin taken by the Japanese longliners was examined. Two migratory routes are found in the most densely distributed areas that cover the waters of the equatorial currents and the Gulf Stream: one is represented by a high hooking rate in the Gulf of Guinea in the northern winter and a westward dispersion in the northern summer, and the other by concentration in the waters north of Brazil in the northern winter and by dispersion toward Florida in the northern summer. The longline mainly catches the species at the feeding phase of adult stage. The immature fish are taken in the neritic waters along the African and South American Continents. Thus, the catch records indicate two segregated groups, the immature stage and feeding phase of the adult stage.

Examination of gonads and larvae indicates, however, that the species actually spawns in the entire waters extending over the tropical zone and western part of the temperate zone.

Conceptions of stock structure other than those defined a priori for the species under discussion may help to explain the structure of the yellowfin population. It is assumed that the population comprises two strata of intraspecific segregation, systematic fractions and space-time groups: two systematic fractions actually exist in the Atlantic Ocean; one being distributed in the area extending between the Gulf of Guinea and north of Brazil, and the other, between north of Brazil and off Florida through the Caribbean Sea. Each of the systematic fractions includes several space-time groups spawned at different times of the year and in different parts of the distribution area. It is not possible to determine whether or not the two systematic fractions actually intermingle with each other. Morphometric and serological investigations and tagging studies are required to corroborate the aforementioned assumptions.

No. 4.4 Assessment of the yellowfin stocks in the Atlantic Ocean

by

Sigeiti Hayasi and Misao Honma
Far Seas Fisheries Research Laboratory, Shimizu

Decline of catch per unit effort (hooking rate) of the yellowfin tuna taken by Japanese longliners in the Atlantic Ocean has attracted attention of fisheries biologists. The density index has decreased and the amount of fishing effort increased continuously over the ten years between 1956 through 1965. A comparison of fishing effort and catch and density index implies that the recruitment might have been stable or on a gradual decrease for this period of years. Development of the surface fisheries along the western coast of Africa might also have affected the stock size, even though lack of systematically compiled catch data prevents us from drawing any conclusion as to the amount of these effects. Analyses of catch records of both types of fisheries are urgently required in order to profitably utilize the stock under discussion.

No. 4.5 The tuna fisheries of Venezuela, with notes on other scombroids of potential commercial value

by

Raymond C. Griffiths
Venezuelan FAO/UNDP Fisheries Research and Development Project
Caracas

About forty Venezuelan vessels engage in commercial longlining for tuna. The majority of these vessels are very small, having been converted from bottom longlining for snappers and groupers, and generally have a capacity of up to twenty tons. There are a few larger longliners of Japanese origin.

Most of the catch (about 2,000 long tons annually) is composed of yellowfin and albacore. Average catch rate measured as numbers per hundred hooks, are 2-3% for yellowfin and up to 1% for albacore. The average catch rate by weight, for total tuna, is about 80 kg/100 hooks. Bigeye blackfin, swordfish and marlin, are also caught.

The chief areas, for the great majority of the fleet, are some fifty to a hundred miles north of the Island of Margarita and near the eastern islands of Los Roques archipelago, and to the south-east of Trinidad; others venture to the southern Lesser Antilles and into the Caribbean.

Differences between the Caribbean and Atlantic fisheries have been found but the data do not allow a rigorous analysis. However, there is an apparent abundance cycle: in the Caribbean fishery for yellowfin it is two-yearly, for albacore yearly; in the Atlantic fishery it appears to be yearly for both species. There are also seasonal cycles, superimposed on the longer term cycles: in the Caribbean fishery the yellowfin show no particular seasonal abundance, whereas the albacore show better catch rates in the first and fourth quarters; in the Atlantic fishery the yellowfin give best results in the second and third quarters, whereas the albacore show best catch rates in the third and fourth quarters. Some general speculations on movements of these species are ventured, and possible effects of regional oceanography on abundance are discussed.

Various morphometric relationships for yellowfin from the Caribbean and western Atlantic are given. A preliminary length-weight relationship based on gutted fish is given.

Some notes are presented on other scombroid resources of actual or potential commercial value; such as "carite" (Scomberomorus), "cachorreta" (Scomber) and "cabaña" (Sarda and Auxis). The annual catch of "carite" exceeds that of tuna but the fishery is much more primitive and ill-defined.

No. 4.6

The blackfin tuna (Thunnus atlanticus) as an unutilized fishery resource in the tropical western Atlantic

by

Bruce W. Maghan
Bureau of Commercial Fisheries, Exploratory Fishing and Gear Research Base,
Pascagoula, Mississippi

This study is based on surface school sightings and catches by the Bureau of Commercial Fisheries exploratory vessels, in the Gulf, Caribbean and adjacent areas, during the past 18 years. Brazil and Cuba are the only countries that fish blackfin tuna commercially in significant quantities. Availability of the blackfin in commercial quantities is demonstrated and the most suitable fishing methods discussed. A distributional map and tables showing abundance and surface temperatures by season are given in addition to statistics on length, weight, production, etc. The blackfin has been recently approved by the US food and Drug Administration for labelling as light meat tuna.

No. 4.7

Oceanographic investigations applied to the tuna fishing in the Caribbean Sea

by

Valerian Yurov, Soviet Specialist

and

Héctor Ramis Ramos
Centro de Investigaciones Pesqueras del Instituto Nacional de la Pesca, Playa Habana

According to the programme of fishery research of the Joint Cuban-Soviet Commission, the CIP has, since 1967, intensified investigations on oceanological conditions related to tuna fishing in the American Mediterranean.

Up to the present, the number of observations in the international waters of the Caribbean Sea were relatively limited and sporadic, but the results were valuable insofar as they helped to organize later oceanographic investigations.

In previous Cuban-Soviet investigations (Jromov, 1965; Bogdanov, 1965) an area of upwelling was detected along the south part of the Caribbean Sea. They also showed that the main reasons for this phenomenon were dynamic processes caused by the trade winds and the system of currents in the area.

The presence of favourable conditions for primary production was thus demonstrated but not until the last phase was it possible to survey its commercial resources. The aim is to establish a tuna fishery on a year round basis and the stations sampled with longlines confirmed the existence of commercial concentrations. It is relatively easy to locate the productive areas following the changes in temperature and the variation of the phosphate content. The location of these areas is demonstrated.

No. 4.8

Observations on the food of skipjack tuna in the Eastern Caribbean

by

Alexander Dragovich
Bureau of Commercial Fisheries, U.S.A.

The food and feeding habits of skipjack tuna (Katsuwonus pelamis) from the eastern portion of the Caribbean Sea were studied during 1965 and 1966. The study concentrated on a qualitative and quantitative analysis of the stomach contents of 369 skipjack tunas. A variety of food items ranging from small plankton to large fish and squid were found in 93% of the stomachs. Most of the food

consisted of pelagic fish (75% by volume) and pelagic cephalopods (22% by volume), and both were most abundant numerically. Crustaceans were present in the tuna stomachs but were of subordinate importance.

Most of the 369 skipjack tunas (329) were caught with live bait; 40 were caught by trolling.

A total of 109 different taxa were identified from the stomach contents - 41 species, 28 genera, 24 families, and 16 taxonomic categories higher than families. Taxonomic diversity was greatest among fishes (87 taxa). In descending order of frequency of occurrence, the most important fishes identified were Scombridae, Auxis spp., Paranthias furcifer, Mullidae, Dactilopterus vilitans, Holocentrus spp., Holocanthus spp., Acanthurus spp., and Gempylidae.

No. 4.9

Larval distribution of tunas and billfishes in the Atlantic Ocean

by

Shoji Ueyanagi
Far Seas Fisheries Research Laboratory, Shimizu

Larval occurrences of Atlantic tunas and billfishes are studied in order to delineate their spawning areas based on data obtained from cruises during 1959 -1967 of the Japanese research vessels.

Larvae of four species of tunas, yellowfin Thunnus albacares, bigeye T. obesus, albacore T. alalunga, skipjack Katsuwonus pelamis and four species of billfishes: white marlin Tetrapturus albidus, longbill spearfish T. pflugeri, blue marlin Makaira nigricans, swordfish Xiphias gladius, are widely distributed in the tropical and subtropical areas. Low limit temperature for the larval distribution appears to be approximately 24°C for most of the tuna and billfish species. This limiting temperature is, however, a little higher (about 26°C) in the cases of bigeye and yellowfin tunas.

Larval distribution of albacore (seldom occurrence of larvae in the equatorial region) may be indicative of separation of spawning areas of this species in the north-western and south-western Atlantic, whereas the larval distributions of other tuna species are continuous from the Caribbean Sea through the equatorial region to the waters around 25°S lat.

No. 4.10

Distribution of post-larval swordfish Xiphias gladius L. in relation to water masses

by

S.N. Tibbo and L.M. Lauzier
Fisheries Research Board of Canada
Biological Station, St. Andrews, N.B.

In February 1965, 47 post-larval swordfish were caught in three regions of the western North Atlantic; near Cape Hatteras, N.C.; off the east coast of Florida; and near the Virgin Islands. The captures were made in waters where the ranges of temperature and salinity were small. The distribution of the smallest larvae suggests one spawning area in Yucatan Channel, and another at the northern edge of the Equatorial Current. The sizes of larvae indicate spawning from mid-December to mid-February.

No. 4.11

Taxonomic status of western Atlantic clupeid fishes

by

Frederick H. Berry
Bureau of Commercial Fisheries, U.S.A.

Fishes of the family Clupeidae of the western Atlantic area are an important food and protein resource. These fishes are probably very susceptive to overfishing, and as yet subject to few management regulations. Scientific knowledge of their biology upon which meaningful regulations can be based is meagre, and taxonomy of many of the species is uncertain. Synopsis of literature and study of speciments suggests that currently 44 species of western Atlantic clupeids should be recognized as valid. Scientific names and known areal ranges are given for these, and known or anticipated taxonomic problems are briefly discussed.

No. 4.12

The present status of the investigation and exploitation of the clupeoid resources of Venezuela

by

John G. Simpson
Venezuela FAO/UNDP Fisheries Research and Development Project
Caracas

The main clupeoid fisheries are for sardine (Sardinella anchovia), rabo amarillo (Cetengraulis edentulus), Machuelo (Opisthonema oglinum), and are practised in eastern Venezuela. The principal fishing areas are in the Gulf of Cariaco, the Gulf of Santa Fe, along the western and northern shores of the Peninsula of Araya and around the Islands of Margarita, Coche and Los Lobos. These species are found in other areas along the Venezuelan coast, but little is known of their distribution and abundance.

The sardine provides the raw material for the world's fifth largest sardine canning industry; the total catch during the last five years has averaged about 40,000 tons per year.

The rabo amarillo and machuelo are used for fishmeal production and the highest catches were recorded in 1965 (4,300 tons) and 1967 (5,000 tons), respectively.

At present, the clupeoid fisheries mainly use beach seines and the fishery takes advantage of the large number of sardine schools which enter the Gulf of Cariaco between about December and May where about 80% of the catch is usually made. The beach seine fishery is beginning to be supplemented by the introduction of small-scale purse seining.

The total annual catches and catch per set for the beach seines from 1957-1967 are examined.

Most biological studies have been made on the sardine and the present knowledge of the taxonomy, early life history, spawning and growth of the species are reviewed. Although most of the sardine catch is Sardinella anchovia, there is a small proportion of a second type, whose degree of taxonomic differentiation is uncertain, and information bearing on the solution of this problem is given.

Descriptions of the early life history, spawning areas, spawning seasons and some notes on the growth of the rabo amarillo are given.

The main fisheries for the sardine, rabo amarillo and machuelo are in the wind-induced upwelling area off the north-eastern coast of Venezuela. This upwelling area has been studied by several research agencies and the main facets of this fertilizing mechanism are described.

No. 4.13

Observations on nightlight fish attraction and experimental fish pumping in the eastern Caribbean Sea

by

Harvey R. Bullis, Jr. and Charles M. Roithmayr
Bureau of Commercial Fisheries. Exploratory Fishing and Gear Research Base,
Pascagoula, Missippi

The Caribbean Sea fauna is relatively rich, both in species and numbers of small clupeoid fishes. Although most of these fishes are small they are ubiquitous, and their growth is rapid. They are basic plankton feeders, which means they are low on the food chain.

The usually narrow continental shelves of the island arc of the Caribbean Sea are mostly rocky and coralline making commercial trawling and the use of gillnets virtually impossible. In the Windward Islands, there are few beaches that would permit beach-seining schools of small fish present in the near-shore waters. Field studies were conducted by the research vessel Oregon in the eastern Caribbean Sea to test a promising method of harvesting pelagic schools of small anchovy, herring, and sardine in shallow island waters.

Extensive observations were made on the attraction of small schooling fishes to nightlights and their susceptibility to capture with an experimental 6-inch (1,500 g.p.m.) fish pump. A total of 17 nights was devoted to these studies at the Windward Islands. Submerged 1,000-watt lights were employed in combinations of from 1 to 4 units with precise intensity control. Species showing direct positive response to various light intensities included Anchoa lyolepis, Anchoviella eurystole, Jenkensia sp., Membras sp., Harengula clupeola, H. humeralis, and Chirocentrodon bleekerianus, all of which appeared in dense concentrations at various times during the observations. Species showing indirect positive response included Opisthonema oglinum, Decapterus macarellus, Trachurus sp., and several other carangids. All of these exhibited some degree of susceptibility to fish pump capture. In addition, incidental captures of larger fishes included miscellaneous flying fishes and large cutlassfish. Highest sustained catch rates were made at Grenada where in one hour 234 pounds of anchovies and sardines were pumped at the rate of 900 to 1,800 fish per second. Samples of the most abundant species were sun dried and analyzed for protein and oil content. Oil varied between 5 and 10%, whereas protein ranged between 34 and 68%.

No. 4.14

A comparative study of some morphometric characters of the anchoveta Cetengraulis edentulus (Cuvier, 1829) from 1962 to 1965 in eastern Venezuela

by

Albis Alcides Ferrer
Venezuela FAO/UNDP Fisheries Research and Development Project
Caracas

The purpose of this study was to determine whether or not certain morphometric characters of the anchoveta, Cetengraulis edentulus, (Cuvier, 1829) present variation from one year to the next. The specimens studied came from 22 samples collected in the Gulf of Cariaco, the north coast of the Peninsula of Araya, the coast of Carupano and the Island of Margarita, during the years 1962, 1963, 1964 and 1965.

In all seven morphometric characters were selected: total length, length of maxillary, height of head, height of caudal peduncle, length of the base of the anal fin, length of the pelvic fins, and length of the pectoral fin.

All these characters were analyzed by means of the "t" test to determine whether or not there is a significant regression (H_o: B=0) between the character measured and the total length, and to ascertain whether or not there were significant differences between one year and the next with respect to the coefficient of regression in respect of each of the characters.

The results demonstrated that the specimens collected in the zone from 1962 to 1965 do not show statistically significant differences with reference to the characters studied, although certain significant differences had been pointed out by Silva (1967) between samples from the Gulf of Paria and those from the States of Sucre and Nueva Esparta in Venezuela, in respect of anal fin rays and gillrakers.

No. 4.15

Distributional patterns of fishes from coastal and shelf waters of the tropical western Atlantic

by

C. Richard Robins
Institute of Marine Sciences
University of Miami, Florida

Studies of the inshore and reef fishes of the tropical western Atlantic show that although most species enjoy wide distributions, few are common to all segments of the region. Patterns of distribution emerge, which, although varying somewhat in specific limits, may be easily defined geographically. Such geographic divisions, however, are meaningfully defined not by latitude, longitude or size of deep-water barriers but by ecological parameters.

Continental species require environments where change is a way of life, change due to seasonal shifts in continental climates unbuffered by broad stretches of ocean, change due to run off from large rivers, and change due to turbidity caused by winds that stir silt rich bottom sediments. Continental species fall into two groups, northern and southern, but some species occur in both areas. Northern species are distributed from eastern Florida mostly south of Cape Canaveral around to Tampa, around the Gulf of Campeche and along the estuary-rich large high islands of Cuba, Hispaniola and, to a markedly lesser degree, Jamaica. Southern species occur along the north coast of Brazil, the Guianas, Trinidad, and Venezuela and in pockets near river mouths from Colombia to Nicaragua. Mixing of the more distinctive elements of both groups is in the pockets along Central America and in the Greater Antilles.

In contrast to continental forms the distinctive and species-rich insular fauna inhabits the islands where waters are clear, environmental conditions buffered, and bottom sediments largely of calcium carbonate. This fauna occurs from the Bahamas, in whose vast shallow-water habitat it is best developed, south to the islands off the coast of South America and it occurs along broad reaches of Central America where the continental shelf is narrow, land run off limited, and where as a consequence clean oceanic waters bathe the shores.

Mixing of continental faunas occurs where the environments themselves mix notably in the Florida Keys and Cuba and along the coast of Colombia and Venezuela.

Not all shore-fish species may be thus categorized. Some are distributed through all the divisions and the distributions of many are too poorly known for comment.

Representative distributions are discussed and the state of our knowledge of the various elements comprising the tropical western Atlantic fish fauna is assessed with recommendations for future work.

No. 4.16

Fishery potential for snapper and grouper in the Caribbean Sea and adjacent South American coast

by

James S. Carpenter and Walter R. Nelson
Bureau of Commercial Fisheries, Exploratory Fishing and Gear Research Base,
Pascagoula, Mississippi

Most fisheries in peripheral areas and banks throughout the Caribbean are dominated by the Lutjanidae (snappers), Serranidae (groupers), and Pomadasyidae (grunts). Local fisheries depend to a large extent on these families through either a hook-and-line fishery or a trap fishery. Local effort is expended on near-shore banks or reefs and is generally confined to relatively shallow waters. Poor condition of landed fish plus inadequate vessels and outdated fishing techniques inhibit the local development of a large foodfish fishery in the Caribbean.

Foreign vessels are beginning to utilize Caribbean snapper and grouper resources. US vessels have landed several million pounds of fish from the Honduran and Nicaraguan shelf area in the past few years.

Past exploratory work by the US Bureau of Commercial Fisheries, FAO, Russian, and Latin American agencies has shown a large snapper and grouper potential in the Caribbean. Caribbean red snapper (Lutjanus purpureus) and blackfin snapper (Lutjanus buccanella) are most abundant down to 50 to 70 fathoms, where they are replaced by silk snapper (Lutjanus vivanus) down to depths of around 150 fathoms. Numerous species of groupers are found with varying degrees of abundance in local areas. Many species of grunts (Haemulon) are found throughout shallower waters of the Caribbean. Lane snapper (Lutjanus synagris) and yellowtail snapper (Ocyurus chrysurus) are also common in shallow waters of the Caribbean and reach heavy concentrations at certain times of the year.

The Bureau of Commercial Fisheries' estimates of resource potential based on commercial landings and exploratory catch extrapolations are to the order of 41,000 tons for the Caribbean.

Immediate increased snapper and grouper production can be realised through adoption of modern hook-and-line fishing techniques (hand powered reels and improved terminal gear) and the installation of preservation facilities aboard the larger class vessels. The hook-and-line fishery is efficient in areas of heavy fish concentration. However, a vast majority of Caribbean areas have widespread small concentrations of snapper and grouper which are not economically feasible to fish with hook and line. Many of these areas are not excessively rough-bottomed and could be successfully worked with roller-rigged fish trawls. Some species, notably silk snapper (Lutjanus vivanus), are often found in heavy concentrations well off rugged bottom and appear to offer a potential midwater trawl fishery.

Caribbean areas of greatest potential both to hook-and-line and trawl fisheries include the Honduran-Nicaraguan shelf, Colombian coast, banks south of Cuba, and Continental Shelf off the Guianas and Brazil. Limited scale fisheries should be sustainable throughout the Antilles, although they would almost necessarily be of a hook-and-line or trap nature, since relatively little trawlable bottom exists.

No. 4.17

The demersal fish resources of Venezuela and their present exploitation

by

Frank Durant and Wilhelm Brandhorst
Venezuela FAO/UNDP Fisheries Research and Development Project
Caracas

Oceanographic conditions suggest that most of the fishery resources of Venezuela are likely to be concentrated in the western and eastern waters, the central zone between the Peninsula Paraguana and about 65° 30' W longitude having less prospects, which is reflected in the total production of 1966 of only 4%.

The western zone, including the Lake of Maracaibo and the Gulf of Venezuela, both characterized by shallow water depth, produced about 23,000 tons and 14,000 tons of fish, respectively. The most important fishes are Manamana (Suprasinelepichthys laticeps) and Bocachico (Prochilodus reticulatus), endemic fresh and brackish water species (both about 6,800 tons); Mullet (about 4,400 tons), a number of other migratory species; sea trouts and sharks. The aforementioned fishes are considered here although they are not strictly demersal species.

The Lake fishery is entirely artesanal, involving some 7,000 to 8,000 fishermen, who use mostly small outboard engined craft and beach seines, sunken gillnets and hand lines.

The Gulf of Venezuela is the location of the only important demersal fishing industry presently developed in Venezuela, which consists of a fleet of about 120 cutter-sized trawlers of 15 m to 27 m in length. These and some additional 160 motor launches plus a few smaller craft are exploiting shrimps, principally for export, and a number of demersal fish species Corocoro (Orthopristis ruber and Haemulon spp.); Roncador or croaker (Micropogon furnieri); Curbina (Cynoscion leiarchus, C. virescens), and others, for the fresh fish market, principally Caracas. The total landings from the Gulf waters amounted in 1966 to about 14,000 tons of fish and the number of fishermen employed to about 1,000.

The central zone extending from about 65° 30' W to 70° W longitude has only limited trawling areas. In 1966 a few demersal species were landed in quantities larger than 200 tons: Lebranche (Mugil brasiliensis), groupers (Epinephelus spp.), snappers (Lutjanus spp.), Corocoro (Orthopristis ruber and Haemulon spp.) Lisa (Mugil curema) and Manamana (Suprasinelepichthys laticeps), of which two are migratory and one fresh or brackish water species, taken near river mouths or in lagoons.

The fishery in the central zone is conducted with one trawler, about 260 motor launches and about 350 small craft partly equipped with outboard motors. The most common gears used are pots and hand lines with about 2,000 fishermen engaged and a total catch of about 5,000 tons.

The eastern zone extending from about 60° W (territorial boundary south of the Orinoco River) to 65° 30' W includes the 50 to 60 miles wide shelf area of less than 100 fathoms depth from the Orinoco Delta to the west of the Isla Margarita. These waters benefit from the vast outflow of detritus-rich water of the Orinoco and other large rivers (Guayana Current) and those in the northern part additionally from local upwelling (around the lee-shores of the islands, Gulf of Cariaco, etc).

The total catch of this zone in 1966 amounted to about 71,300 tons, most of which is taken between Boca de Drago (61° 50' W) and 65° 30' W.

There are about 10,500 fishermen working in this zone and the fleet consists of about 110 smaller offshore vessels, about 500 motor launches and 1,400 smaller-sized crafts. About 80% of them are motorized. The most important gear used are beach and purse seines, hand lines, pots, throw nets, gill and tangle nets.

No modern trawl fishery is developed. In 1968 only 8 trawlers were operating in the zone, from Cumaná and Puerto La Cruz. A few exploratory surveys aimed at evaluating the prospects were carried out from 1962 to 1964 with modest results.

Only about 14% of the 1966 total catch consisted of demersal fish species. These were principally snappers (Lutjanus spp.), Catfish (Arius spixii and others), Lisa (Mugil spp.), Corocoro (Orthopristis ruber, and Haemulon spp.), sharks (Isurus, Carcharhinus, Sphyrna, Mustelus and other genera); groupers (Epinephelus spp.), and Lebranche (Mugil brasiliensis).

No. 4.18 Shrimp resources of the Caribbean Sea and adjacent regions

by

Milton J. Lindner
Bureau of Commercial Fisheries, U.S.A.

In the western Atlantic Ocean between Cape Hatteras, U.S.A., and the delta of the Orinoco River, Venezuela, only 10 species and subspecies of shrimp (all penaeids) are considered to be of present or potential commercial importance (assuming no major changes in fishing gear). The ranges and concentration localities are given for each species.

Some of the problems in determining the fishable magnitudes of shrimp stocks from knowledge of species ranges, trawlable areas, and exploratory fishing are discussed. Additional ecological and catch-effort data are required for more precise estimates of potential production from the various stocks.

Apparently, no large stocks of Penaeus remain undiscovered in the area. Practically all are fished at or near their maximum levels under present fishing conditions.

The stock of Penaeus setiferus in the northern Gulf of Mexico, and perhaps elsewhere, may have been overfished for more than 20 years. Stocks of P. a. aztecus and P. d. duorarum in U.S.A. waters do not seem to be overfished.

Total annual shrimp landings for the entire area considered are estimated to be about 125,000 metric tons. An additional 20,000 tons might be expected from increased fishing effort.

By better management of the shrimp stocks in waters of the United States, it is estimated that the annual landings could be further increased by 15,000 to 40,000 metric tons.

No. 4.19 The state of the shrimp resources in Venezuela

by

J.J. Ewald
Venezuela FAO/UNDP Fisheries Research and Development Project
Maracaibo

Shrimp support the most economically important fishery in Venezuela. An expanding world market has kept the export price very favourable and dramatic expansion and modernization of the fishing effort has resulted over a relatively short period of time. The major exploitation is found in Western Venezuela (Gulf of Venezuela and Lake of Maracaibo) where 134 trawlers and approximately 2,000 small boat fishermen produced 4.786 metric tons in 1967. This represents 94% of the total national production of shrimp. Lesser amounts are taken from the coastal waters of north-east Venezuela by small boat fishermen and by trawlers fishing areas adjacent to the Orinoco delta and the deeper waters north-east of Margarita.

Exploitation of Venezuela's shrimp resources began in 1958 when the large shrimp populations in the Gulf of Venezuela were discovered by Italian-type trawlers operating out of Puerto Cabello. National production steadily increased from 1,128 metric tons in 1958 to a high of 7.473 metric tons in 1965 due, at least in part, to the arrival of additional boats, the change in gear from the Italian-type trawls to the American otter trawls, and a relaxing of some government regulations affecting fishing in the Gulf.

From 1964 to 1965 the production in both the Lake of Maracaibo and the Gulf of Venezuela almost doubled and processing facilities were not adequate to take care of such an increase. Plant and boat owners immediately made plans for expansion and freezing capacity was approximately doubled. New boats were ordered. In 1965 production dropped and considerable hardship resulted. A more cautious optimism currently exists with this year's increased production.

The only sustained study of Venezuela's shrimp resources prior to this year was that of the Instituto Venezolano de Investigaciones Científicas which, (for three and a half years) with financial

support from the Ministry of Agriculture, studied certain aspects of the biology of Lake Maracaibo and Gulf of Venezuela shrimp stocks. A general idea of size and species distribution was obtained from a systematic sampling of the commercial catches. Ten penaeid species have been identified from the commercial samples, and of these, four are of commercial importance (P. schmitti, "camarón blanco"; P. duorarum,"camarón rosado"; P. aztecus, "camarón marrón"; and P. brasiliensis, "camarón rosado con mancha"). White shrimp are fished in the Lake and Western Gulf (Calabozo) and the red and brown shrimp, in the higher saline waters of the outer Gulf. Because of the importance of the white shrimp in the area and because the Gulf possesses probably the largest concentration in the world of this species, IVIC emphasized its study during the last three years. A recently completed tagging programme has confirmed suspicions that the Lake is a large nursery area for the adult white shrimp of the Western Gulf. Juveniles tagged in the northern Lake were recaptured a month later near the Colombian coastal border. The drastic drop in production seen in 1966 resulted from a sizeable reduction in Lake and Gulf white shrimp stocks. No explanation has been found for this.

No large shrimp populations have yet been discovered in eastern Venezuela. Of special interest are the areas adjacent to the Orinoco River Delta where both a fisherman and a biologist would expect such. The La Salle Foundation and several private concerns have explored the area, somewhat sporadically.

The Demersal Resources Programme of the newly established Fisheries Research and Development Project (MAC-UNDP-FAO) in Venezuela plans to continue, on an expanded scale, the study of shrimp stocks of Western Venezuela and systematically explore areas in the east.

No. 4.20

Observations on the biology and fishing of white prawn

by

Marcela Olguín and María Emilia Ruiz de Quevedo B.
Centro de Investigaciones del Instituto Nacional de la Pesca
Playa Habana

The basic objective of this paper is to establish, with the help of some oceanographical, biological and statistical data, the periods and areas for possible conservation of the white prawn Penaeus schmitti.

The material for this work is derived from commercial prawn boats, sampled every month at three stations around the mouth of the Zaza River (Tunas de Zaza, las Villas and south-eastern region of Cuba). It is believed that the area used for this study has ecological conditions and fishing characteristics very similar to all areas where the prawn is caught at present.

Some statistical observations are made regarding the rhythm in growth rate, and variations in the behaviour in relation to environmental factors are anlysed. The growth period, spawning time and the recuperation period for the populations found in this area were studied.

Recommendations are formulated with a view to obtaining a higher yield resulting from more rational fishing.

No. 4.21

Results of the oceanographic investigations made at Bahía de Cienfuegos in October 1967 seen in relation to prawn distribution

by

Nikolai Bessonov, Anatoli Elizarov (Soviet Specialists)

and

Héctor A. Santana
Centro de Investigaciones Pesqueras del Instituto Nacional de la Pesca
La Habana

In the last few years an increased interest shown in Cuba in fish production of the continental shelf has also widened our knowledge of its oceanographic conditions.

The Bahía de Cienfuegos, of great prawn fishing tradition, presents ideal conditions for a systematic comparative fishing and oceanographic investigation, using an appropriate methodology for these continental shelf areas with estuarine characteristics.

The month of October following the rainy period was chosen since it was considered ideal as far as the oceanographic conditions are concerned.

The most striking features in this part of the year are: a marked stratification of the waters and a very reduced transparency. The reasons for the stratification are based on the presence of two types of water in the bay; one on the surface of reduced salinity (fluvial influence) and another of deeper oceanic origin.

The general direction of the surface water is southward along the canal. The deeper waters in a northern direction come from the open sea. As a consequence of the transversal circulation of the surface waters and of the predominant winds from the north-east, upwelling occurs of the water along the NE of the Bay.

In this NE region the areas of prawn fishing are located. The greatest horizontal gradient of the hydrologic characteristics and a general relative decrease of its vertical gradient were observed in this area. This is related to the decreased stability of the water layers. The highest salinity observations and low values of O and pH content were also observed in this area.

The most favourable oceanographic conditions for the prawn resulting in a high concentration of organic matter are caused by coastal drainage into the Bay and by high primary productivity, especially in the south-west region.

No. 4.22 Progress in shrimp mariculture in the United States

by

Milton J. Lindner and Harry L. Cook
Bureau of Commercial Fisheries, U.S.A.

Larvae of the three commercially important penaeid shrimp native to the United States - Penaeus aztecus, P. setiferus, P. duorarum - have been cultured in the laboratory. Cultures of larvae yield about 50 postlarvae per litre of sea water, or 47,000 in a 940-litre tank. Recent research has shown the value of culturing shrimp larvae under conditions where all environmental factors can be controlled. Survival of brown shrimp larvae is increased substantially by holding nauplii in water of 24° C, and then gradually increasing the temperature to 32° C as development progresses. The density and quality of food determine the number of larvae that can be grown in a given volume of water, and culturing efficiency can be increased by maintaining food at optimum levels.

Young shrimp grew rapidly in ponds which were fertilized, but to which no supplemental food was added. In one experiment, white shrimp grew from 12 mm to 92 mm total length in 5 weeks. In all experiments, growth slowed and eventually stopped when the shrimp were between 80 and 100 mm. Supplemental feeding will accelerate the growth of large shrimp, but the foods tested so far did not support growth comparable to that in wild populations. In most ponds survival was high, and the few large mortalities were attributed to oxygen deficiency.

The number of organizations conducting research on shrimp culture is increasing, and considerable advancement can be expected in the near future. Within the next year at least 12 government or university agencies will be conducting research; at least four private concerns are now in operation or planning to start in the near future, and four industrial groups are supporting research.

No. 4.23 **Spiny lobster fishery in the Caribbean**

by

C.P. Idyll
Institute of Marine Sciences
University of Miami, Florida

Spiny lobsters (family Palinuridae) are exploited in most coastal areas of the Caribbean. The principal species caught is Panulirus argus. Catches are largest in British Honduras, Nicaragua, Puerto Rico, Jamaica and Mexico. Statistics of landings are variable in accuracy and completeness and no valid total is available for the region. The fishing methods used are principally traps, bully nets and by diving.

The life history of P. argus has been determined in general, but in many areas the details of reproduction, growth and other aspects are not available.

It is likely that spiny lobster fisheries can be expanded in some areas of the Caribbean but most lobster stocks appear to be fully exploited.

No. 4.24 **Colour scale for the study of the cycle of reproduction of the langosta in the Caribbean Sea area**

by

René J. Buesa Más
Centro de Investigaciones Pesqueras
Instituto Nacional de la Pesca
Playa Habana

and

María Ivone Mota Alves
Estação de Biologia Marinha
Universidade Federal do Ceará

The biology of the langosta Panulirus argus (Latr.) was analysed over the area of its geographical distribution. The use on a regional basis of a colour scale for establishing the reproductive seasons and the release of planktonic larvae of the species is recommended. It is hoped that this study might contribute to the question of the possible Caribbean origin of the langosta of Florida.

No. 4.25 **On the biology of the lobster in Cuba**

by

Gerardo Suárez Alvarez
Centro de Investigaciones Pesqueras del Instituto Nacional de la Pesca
Playa Habana

The aim of the investigation of the Cuban lobster Panulirus argus (Latr.) is to contribute to a rational utilization of this resource. The study of the lobster started with a small sampling programme, and not until 1962 could the work be expanded in the form of a systematic sampling in the harbours. Four exploratory trips and one experimental were made.

The study of the biological cycle has been valuable. The reproductory activity takes place in the spring and also about half of the growth cycle for males. Females produce two consecutive spawns, the second smaller than the first. Egg counting gave a number close to half a million eggs for both spawning periods together. Larger females had less number of eggs. The ecdysis lasts five months in summer and seven months in winter. The recruitment of larvae occurs all year round, with a maximum from November to March. The larval cycle lasts 6 to 8 months, that of post-larvae around 14 months. Maturity is attained in the fourth year (210 mm total length).

We have collected data on age and other parameters for the study of the population dynamics. The theoretical relation between weight and length is given by the formula $W = 10^{4}.1,5653^{2,7102}$. A total of 835 post-larvae were kept alive in the aquarium and their growth was studied.

From marking experiments we concluded that the seasonal migrations were made in search of areas richer in food. The metabolic rhythm was studied and it was found that in the areas where lobster is abundant, the habitat has the same environmental characteristics as those found in the optimum conditions in the laboratory. The oxygen consumption for specimens 4-5 years old is 69-73.5 μl O_2/gr/hour at 29.2° C.

Ecological relationships were studied and a group of six epizoocommensals were found. Alimentation was studied from analysis of stomach contents.

Survival experiments showed that lobsters could be maintained out of water for ten days and still live after being returned to the water.

No. 4.26

Physiological aspects of some marine invertebrates of commercial interest in Cuba

by

Gerardo Suárez A. and R. Xiqués Diaz
Centro de Investigaciones Pesqueras del Instituto Nacional de la Pesca
Playa Habana

The Institute of Oceanology of the Academy of Sciences of Cuba and the Centre of Fisheries Research started studies on the physiology of species of commercial importance separately but now the work is coordinated.

The investigation programme for the different organisms has covered respiratory processes, to study the oxygen used in relation to size, sex, temperature, salinity and survival out of the water. Values found for the consumption of oxygen were: for Panulirus argus 69-73 $\mu l O_2$/gr/hour at 29° C; Penaeus schmitti 263 $\mu l O_2$/gr/hour at 25° C; Menipe mercenaria 6-32 mg O_2/specimen/h 26° C; Callinetes sapidus 60-70 $\mu l O_2$/gr/hour at 26° C; Crassostrea rhizophorae 69-143 $\mu l O_2$/gr/hour at 21°-26° C.

Feeding was studied by providing the animals with enough food and determining the amount eaten in order to assess the optimum amount required per specimen. Cannibalism in the pools was reduced by adequate feeding.

We studied also the energy balance, which is of great importance for calculating the metabolic rate and the energy in the ecosystem of each species, and also for its adjustment and introduction in new areas, its development and culture in quantities.

The relationship between the food intake and weight can be formulated in M. mercenaria as follows, $r = 0,1377\ W^{0.665}$. The nutritional value for P. argus is 0.68 cal/gr and for M. mercenaria 0.55 cal/gr.

The expenditure of energy during respiration of P. schmitti is 600-1900 cal/gr. It is important to know this value since it is directly related to the behaviour.

The survival in waters of different salinity was studied for the purpose of obtaining information about the behaviour of the different species in the rain period which can induce the animals to migrate or cause their death. The consumption of oxygen at different concentrations of salinity provides information regarding the quantity of water required for survival. We also studied the behaviour, respiration, survival and food during the storage period.

We succeeded in keeping the lobsters out of the water for a period of 10 days and oysters for 15 days. Lobsters lost 5% in weight but there was no loss for oysters.

No. 4.27 The possibility of molluscan mariculture in the Caribbean

by

R.W. Menzel
Department of Oceanography
Florida State University
Tallahasee, Florida

The culture of molluscs, gastropods and pelecypods, is not practised extensively in the Caribbean region. Species of these molluscs are harvested, the source being natural recruitment. The fishery for the queen conch, Strombus gigas, ranks second in importance to the fishery for spiny lobster in some areas and the harvest probably could be increased with proper management. The culture of this snail probably would not be feasible because of its life history but would merit attention. Oyster and clam culture is widely practised and the techniques should be applicable to the Carribbean, if suitable species can be found. In some areas there is a limited culture for the native oyster, Crassostrea rhizophorae, but this species is of relative small size and probably will never support a large fishery.

There is a good possibility that a clam fishery can be established. The southern quahog clam, Mercenaria campechiensis, is native to the South Atlantic United States, the Gulf of Mexico and at least part of the Caribbean (listed from Cuba). This species has rapid growth but the undesirable commercial feature in that it gapes soon after removal from the water and spoils. The northern quahog, M. mercenaria, keeps for extended periods of time after removal from the water, and is harvested extensively along the Atlantic United States and into Canada. The two species hybridize readily in the laboratory and produce fertile offspring. It should be possible, through hybridization and selection, to obtain a strain that is adapted to the warmer waters and also have the desirable commercial characteristics of the northern form. Techniques for spawning and rearing clams have been perfected and preliminary observations in northern Florida have shown that they can be cultured commercially, if the clams are protected from predators.

In an investigation of the systematic relationships, species of oysters of the genus Crassostrea have been obtained from wide sources, including tropical areas. Preliminary observations indicate that several of these species would be suited to the Caribbean area. One species (C. iredalei) from tropical Philippines has a pleasant flavour and had excellent growth during the warmer water temperatures (up to and over 30° C). Other species that might be successfully grown in the Caribbean region have been secured from Australia, Brazil and South Africa. Oysters are subject to a multitude of diseases and predators and these factors should be investigated, especially if species are introduced.

Another possibility to establish oyster mariculture is the use of hybrids that combine the desirable characteristics of the parents. C. rhizophorae, native to the Caribbean, hybridizes readily with C. angulata and C. virginica. Both of the latter two species are larger oysters than C. rhizophorae and both species support large fisheries. The techniques for rearing oyster larvae in hatcheries have been perfected and are being practised on a commercial scale where the supply of natural recruitment is limited. Oyster culture is widely practised and the practices of other areas could be modified for the local conditions.

No. 4.28. Status of the biology and culture of molluscs in Venezuela

by

R. Martinez Escarbassiere
Venezuela FAO/UNDP Fisheries Research and Development Project
Maracaibo

Abundant natural populations of several molluscs exist and are being exploited along the extended shoreline of Venezuela. The most important of these are the mussel, the oyster, and the famous pearl oyster of Margarita. Only within recent years has concern for rational exploitation of these natural populations, and the possibility of supplementing of the natural production by raft culture to meet expanded demands, stimulated interest in biological investigation. As late as 1962 the Instituto Oceanográfico of the Universidad de Oriente first began such research.

The local mussel (Perna perna) has been harvested sporadically from natural beds for canning and direct consumption. Annual catches range from 150 to 250 metric tons worth about $160/ton. Mussel raft culture, such as practised in Europe, was first attempted in 1960 by private individuals and in 1962 the Instituto Oceanográfico, supported by funds from the Venezuelan government, began biological and technical studies with the objective of testing the feasibility of large scale raft culture. In 1964 the Centre of Fisheries Investigations of the Ministry of Agriculture in Cumaná initiated a pilot project consisting of 30 rafts. Rafts consisted of bamboo and wood floated by Styrofoam Floats. From these rafts bamboo poles containing seed were suspended. Results have been much less than expected due to deterioration of the rafts by action of marine borers and burrowing crabs. Meat production has not been satisfactory. Recently, studies of the larval history of the mussel and the plankton of the surrounding waters have been undertaken to try to solve two basic problems: the difficulty of obtaining "seed" mussels when needed and the reason why the project mussels did not grow as expected. New rafts made of oil drums and using suspended automobile tyres are currently being tested.

The demand for the edible oyster (Crassostrea rhizophorae) and the indiscriminate destruction of seed beds has stimulated both the Instituto Oceanográfico and the Centre for Fisheries Investigations to consider the possible "artificial culture" of oysters.

The once famous pearl fishery (Pinctada imbricata) of the island of Cubagua near Margarita has suffered from the competition of the Japanese cultivated pearl and from the apparent reduction in number and size produced by the natural population. Recent trends suggest that the pearl oyster should be used for human consumption. Exploitation is regulated by the "Pearl Fishery Law", which permits fishing every two years. In 1948 Galstoff proposed a plan for exploitation but this has not been put into effect.

No. 4.29

The molluscan resources of the Gulf of Mexico and of the south-eastern United States

by

Gordon Gunter
Gulf Coast Research Laboratory
Ocean Springs, Mississippi

In the State of Georgia the tide is so high and the change of salinity is so great that the molluscs do not exist in great quantities near the coast.

On the coast of the Gulf of Mexico west of Florida, Alabama to the Bay of Campeche, no molluscs are fished except for the oyster, Crassostrea virginica. The centre of production is the State of Louisiana. There are several other edible species in this same region.

Florida produces oysters, two species of scallops, two sorts of clams, and sometime conchs and the little clam, Donax, and others.

In the whole region considered, it is possible that the production of molluscs could be raised ten times greater than the present, if all the species present were utilized.

No. 4.30

Exploitation of the mangrove oyster and the possibilities for its culture

by

Miroslav Nikolíc and Santiago J. Alfonso Meléndez
Centro de Investigaciones Pesqueras del Instituto Nacional de la Pesca
Playa Habana

The present paper presents some biological data of this species, characteristics of the habitat and ecological conditions, along with catching methods and gears.

Some results on culture experiments are also presented such as description of the area selected for the cultures, installations and equipment used, collectors and types of cultures which gave the highest yields, etc.

Measures for a rational management of these resources to stock new areas and to promote artificial culture for the purpose of increasing the production are recommended.

No. 4.31 Some biological observations on the mangrove oyster

by

Miroslav Nikolíc and José Soroa Bofill
Centro de Investigaciones Pesqueras del Instituto Nacional de la Pesca
Playa Habana

The present contribution has the purpose of presenting some morphological, dimensional, weight and sexual characteristics of the mangrove oyster. Of 1487 individuals, measurements of the principal dimensions (height, width and depth) and weight, (total weight, weight of the conch and weight of the edible part, "meat") were taken in three important oyster producing areas of Cuba. Seventeen classes, with 3 mm intervals, were established. Due to great varieties in forms between different dimensions a curved line was found. Between the weights as well as between one dimension and different weights, straight lines were obtained. For 2792 individuals maturity stages of gonads and distribution of these stages during seasons were determined; percentual relations between sexes and minimum sizes for each sex were obtained.

No. 4.32 Comparative study of the chemical composition of mangrove oyster in different localities of the east coast of Venezuela

by

Jaime Bonilla Ruiz
Instituto Oceanográfico
Universidad de Oriente
Cumaná

The present paper deals with the chemical composition of the meat of the oyster Crassostrea rhizophorae. Analyses were made to find the months of highest content of fattening indicators (hydrocarbons, fat, etc.) and the type of sub-stratum, in relation to the chemical composition and environmental conditions. It was also necessary to determine the spawning season, since its exact timing can be the most important factor for the distribution of larvae collectors.

The highest values for hydrocarbons, fats, etc., were found during the months of March and April in Laguna Grande and Mochima Bay and in a similar way during the period of lowest temperatures in Laguna Las Maritas during the month of August.

In May and June (1966) the content of hydrocarbon decreased strongly due probably to the spawning; but in 1967 the spawning was slower and continuous from May to October, showing a minimum for the hydrocarbon content from November to January, a period which is believed to be sexually inactive. This occurred in Laguna Grande and Bahía de Mochima; but in Laguna Las Maritas (1967-1968) spawning activity was from September to March.

It is believed that the difference between the fattening and the spawning months found in Laguna Las Maritas and other places studied is due to environmental conditions.

Certain differences were observed in the chemical composition of oysters from the various localities studied.

No. 4.33

Experimental cultures of oysters on the east coast of Venezuela

by

Aníbal Vélez
Instituto Oceanográfico
Universidad de Oriente
Cumaná

From June 1967 to June 1968 several experiments and trials were carried out regarding the culture of oysters, Crassostrea rhizophorae in two small bays called Laguna Grande del Obispo and Bahía Mochima, on the north-eastern coast of Venezuela. These water masses are characterized by the mangrove formation (Rhizophora mangle), the roots of which act as substratum for the oysters. Both water salinity and temperature show only small variations, from 36 to 37 ‰ and 26° to 30° C, respectively.

Two types of collectors were used with a double function for collecting and rearing the seed. The first type was made by wooden frames 100 x 60 cm covered with tar and was placed horizontally tied to the mangrove roots. The second type is a modified version of the Japanese collector and consists of chains of shells. We used mussel shells Perna perna (L). These collectors were placed between the high and low tide lines, tied to the mangrove roots.

Once the post-larvae (spat) was attached and attained 20 mm long, both types of collectors were suspended in a floating device some 20 m away from the shore where mangroves were scarce. To avoid the attack of predators the collectors were placed at a height no less than 60 cm from the bottom.

During the experiments we noticed continuous emissions of larvae for the whole year, with peaks, in January-February, in May-June-July, and in September. Nevertheless the fixing was interrupted in January-February due to the abundance of Balanus sp.

As a result of the movements of the larvae towards the water surface, the wooden collectors, that were kept always floating, got bigger quantities of larvae than those made of shells. But poorly fixed and overcrowded specimens are easily lost before the commercial size is attained. Also the abundance of Teredo sp. prevents the use of this type of collector for more than two seasons. On the other hand the shell collectors proved to be more economical, easier to handle and clean, and offered an excellent surface for fixation.

In general we can say that Bahía de Mochima offers better conditions for the collection of seed than Laguna Grande del Obispo, where the great amount of space competitors, especially Enteromorpha flexuosa, invade the collectors with interference for the fixing of oyster.

No. 4.34

Identification of some predators of the mussel (Perna perna) under experimental conditions

by

Luis José Urosa
Instituto Oceanográfico
Universidad de Oriente
Cumaná

Several experiments to identify predators of the edible mussel Perna perna (Linnaeus 1758) were made with sea water using experimental cages made of metallic screen with a mesh of about 4 mm.

A sub-littoral area was selected with a depth of 0.90 m measured from the tide line, in Turpialito, a little cove of Sucre State, Venezuela.

Water temperature and salinity had an average of 25.5° and 36.78 ‰ respectively, with small fluctuations during the experimental work. The biological material used came from neighbouring localities, in the northern part of the Sucre State.

The predators found were the gastropods, Cymatium cf. parthenopeum, Murex brevifrons and Thais haemastoma floridana and the decapods Callinectes danae and Menippe sp., Cymatium of the gastropods and Callinectes of the decapods being specially destructive.

No. 4.35 The cephalopod resources of the Caribbean Sea and adjacent regions

by

Gilbert L. Voss
Institute of Marine Sciences
University of Miami, Florida

The fisheries for squid and octopus in the Caribbean region has not been developed to near its potential in any country. The ommastrephid squids which form the basis of most squid fisheries in other regions (Japan, Newfoundland) are not fished. The squid fishing is based upon four species, Loligo pealei, L. plei, Lolliguncula brevis and Sepioteuthis sepioidea. All of the fisheries are incidental to other fishing efforts, principally for shrimp and scale fish, and statistics are difficult to obtain and largely meaningless. Most squid products are imported from Spain and Portugal but local resources could easily be developed.

Octopus are also fished throughout the Caribbean with four species involved: Octopus vulgaris, O. briareus, O. macropus and O. maya, although at least four more shallow water species occur in the region. The fisheries are very local and supply only the local areas. The only significant octopus fisheries in the western Atlantic occurs at Campeche, Mexico, where O. maya is loaded during the fall in quantities as high as ten tons per day.

The peoples of the countries bordering the Caribbean represent a strong potential market for cephalopods. However, they are not accustomed to eating the dried product. Cephalopods are either eaten fresh or packed in olive oil with their ink. The latter process may mitigate against the development of a canning industry in the Caribbean.

No. 4.36 Sharks of the Guianas

by

P. Fourmanoir
ORSTOM, Paris

In 1967 some information on 17 species of sharks from the continental shelf of Guianas was obtained on board the R/V Calamar (UNDP) from two shrimp trawlers of the PIDEG and from a red snapper boat, the San Onofre. These are described.

Observations near the coast of French Guianas are rare due to the low fishing activity there. Indications on the presence of large sharks were obtained by line fishing.

No. 4.37 Sea turtle resources of the Caribbean and Gulf of Mexico

by

Archie Carr
Department of Zoology
University of Florida, Gainesville

The five genera of sea turtles are one of the classic resources of the New World tropics. They are at present on the verge of disappearing from the Caribbean as economic assets, if not as natural species. Growth of human populations along Caribbean shores and popularization of turtle products have stimulated a marked and evidently insupportable increase in exploitation. Effects of this were reflected during the 1968 season at the nesting ground of the green turtle at Tortuguero, Costa Rica. Arrivals of nesting females there, were only one-sixth of those in 1965, the last previous nesting

year of the main component of the 1968 year group. Tortuguero is the chief nesting centre for the population of the western half of the Caribbean, as has been shown by returns from a tagging programme under way there since 1955. The only other Caribbean locality in which mass nesting occurs is Aves Island, a Venezuelan possession off Monserrat in the Leeward Islands. There, raiding of the rookery by boats from the adjacent islands is hindered only by the navigation problem involved in finding the tiny island. To save Chelonia and other sea turtle species, and rehabilitate the resource as a source of food and revenue for Caribbean countries will require international cooperation in developing programmes of legislation, management and research. Six preliminary steps toward such a campaign are recommended. Unless such an effort is made the present decline in the resource seems sure to accelerate, an important source of food from the sea will be lost, and some species of turtles may disappear from the Caribbean.

No. 4.38 A general resumé of Oregon Caribbean fishery exploration, 1956-67

by

Harvey R. Bullis, Jr, and John R. Thompson
Bureau of Commercial Fisheries, Exploratory Fishing and Gear Research Base,
Pascagoula, Mississippi

Since the early '50's, the Bureau of Commercial Fisheries exploratory fishing vessel Oregon has been devoting a portion of its cruise time to Caribbean explorations. This has been done as a logical outgrowth of explorations in the Gulf of Mexico in that the Caribbean is also of interest to Gulf fishermen.

Explorations have been carried out with commercial-type gear - principally longlines for pelagic fishes, bottomlines, shrimp trawls, and dredges for bottom-dwelling fishes and shellfish.

Principal resources uncovered - tunas, shrimps, snappers and groupers, herring-like fishes, sharks, and miscellaneous fishes and crustaceans - appear to hold great promise for fishery expansion. Basic exploratory work has been carried out in most areas of the Caribbean. Detailed and intensified follow-up is needed.

Additional cruises, using the new Oregon II, are planned for 1968 and subsequent years. Major emphasis will be on fish trawling investigations.

This paper divides the Caribbean into four quadrants, and discusses the exploratory effort to date and the resource potentialities of each in light of our findings.

No. 4.39 Exploratory fishing activities - UNDP/FAO Caribbean Fisheries Development Project

by

W.F. Rathjen
Caribbean Fisheries Development Project
Bridgetown

Exploratory fishing operations have been conducted by the Caribbean Fisheries Development Project since the fall of 1966. Three combination style vessels have been available to the Project for a total of sixty vessel months through October 1968. The area of operations includes the waters of the Carribean Sea from the edge of the Central American continental shelf east to the arc of the Lesser Antilles. Territorial and near adjacent waters of the Central American Republics as well as those of Colombia and Venezuela are not under the direct scrutiny of the Caribbean Project, but are included in studies by associated Projects. In the Atlantic adjacent to the Caribbean some explorations have been made in the waters near Hispaniola, Puerto Rico and the Lesser Antilles and along the South American continental margin between Trinidad, and the border of French Guiana and Brazil. In all, about one and a half million square miles of area are of potential interest to the Project on behalf of the sixteen participating governments.

Explorations may be divided into two general categories, pelagic and demersal. The pelagic investigations completed to date have been concerned primarily with determining the availability of tunas and related pelagic species. In particular, two methods were employed, long lining for deep swimming species and live bait fishing for surface schools. Limited operations have included other techniques such as trolling, gillnet and lift-net fishing. Studies on demersal species were effected by the use of trawls

particularly along the South American continental shelf and by the use of mechanical reels and conventional hook and line fishing along the reef and limestone bottoms typical to much of the area. As part of the line fishing work, recent demonstrations have included the use of dories operated from one of the Project vessels in a type of "mothership" operation. Other more or less incidental bottomfish investigations have made use of experimental traps of several designs, set lines and acoustic surveys.

Hydrographic observations have been made from Project vessels. In cooperation with other agencies, drift bottle and fish tagging releases are routine.

Biological material is collected and distributed to interested individuals and institutions. Space on the vessels has been made available for observers and cooperators. On occasions, activities of the vessels have been modified to be compatible with training and marketing segments of the Project.

The results of the Project investigations are disseminated through cruise reports and logs as well as by other media.

No. 4.40 Analysis and development of the marine resources of a region

by

Niels Rorholm and Nelson Marshall
University of Rhode Island
Kingston R.I.

In accounting for marine resources it must be realized that the marine environment created by the meeting of land and sea is as important a resource as the biological and mineral resources that are usually described.

This is particularly true in an area such as the Caribbean Sea where the marine environment is extremely favourable to diverse developments.

The authors hold that the study of an area's marine resources cannot be usefully approached through separate studies of individual resources, for this ignores the interaction among the various uses of the sea and associated land areas. Rather, studies in various professional fields must be coordinated at their inception, and these studies must be executed in a manner which reflects a common goal.

The ultimate goal of marine resource studies should be the optimum social and economic growth of peoples in the areas concerned. For this reason it is important that social and economic studies of concerned nations or regions proceed simultaneously with oceanographic studies of marine resources. This common goal of working toward resource development requires a degree of cooperation and mutual understanding among social, physical, and biological scientists which has not, heretofore, been accomplished on a very large scale, but which is essential if marine resources are to be of maximum benefit to mankind.

Finally, it is emphasized that the people of areas or regions who will be responsible for development programmes must be involved at the inception of studies and during the evaluation of results.

No. 4.41 Aerial photo reconnaissance of surface schooling fish

by

Norman L. Pease
Bureau of Commercial Fisheries
Exploratory Fishing and
Gear Research Base
Pascagoula
Mississippi

and

Kirby Drennan
Bureau of Commercial Fisheries
Aerial Fishery Survey Program
Exploratory Fishing and Gear
Research Base
Pascagoula, Mississippi

The Bureau of Commercial Fisheries research vessel Oregon has conducted exploratory fishing cruises periodically to the Caribbean Sea since 1952. During these operations, 42 species of pelagic schoolfish, ranging in size from tiny anchovies to large tuna, have been observed near the surface, in water depths

from 1 to over 2,000 fathoms. Their ubiquitous habits have made it difficult to obtain valid assessments, using only surface vessels, over such broad oceanic areas. To assess these resources, it is necessary to survey wide areas in relatively short periods of time. Information collected should include the location, identity, and an estimation of school sizes. This would help the development of commercial use of these resources by providing current information on their availability.

Since 1966, the Exploratory Fishing and Gear Research Base, at Pascagoula, Mississippi, has conducted research to determine whether aerial photography could provide this information. Multispectral photographs and spectroradiometric measurements have been obtained from a number of surface and near-surface fish schools in the eastern and northern Gulf of Mexico to determine the spectral characteristics of individual species. It is expected that this will lead to identification through the use of either aerial photography or other remote sensing techniques.

The potential application of aerial photography and other remote sensing techniques to the commercial fishing industry are considered. These include: 1) a determination of the fishery potential in terms of availability and degree of utilization of fishing grounds, 2) location and utilization of populations of edible fish inhabiting offshore areas, 3) systematic appraisal of near-surface fishery potential of wide areas of the Caribbean Sea, and 4) monitoring fishing activities and observations of fish concentrations and movements over space and time. The economic significance of the methods considered are also discussed.

No. 4.42

Fishery explorations and connected oceanographical research in Cuba

by

José Ramón Gonzalez Cardulís
Centro de Investigaciones Pesqueras
del Instituto Nacional de la Pesca
Playa Habana

and

Darió Guitart Manday
Instituto de Oceanologia
Playa Habana

The present paper is a summary of the fish surveys and connected oceanographic investigations carried out by the Centre of Fishery Research of the National Fisheries Institute and by the Oceanological Institute of the Academy of Science of Cuba.

From the start of these investigations in 1962 more than 40 cruises have been made with research vessels equipped with the most modern fishing gear. A great number of specialists have participated in the trips and valuable technical help was received from FAO, UNESCO, USSR, and others.

The programmes comprise a great variety of problems, from the study of the environmental characteristics to the productivity in the area. Also, included are the main fishery resources and references are made to previous works on marine geology, microbiology, parasitology, physiology, etc.

The work includes an appendix on the bibliography of marine biology published in Cuba.

No. 4.43

Exploratory fishing on the north and northeast coast of South America

by

Hno. Ginés, F. Cervigón and R. Gómez
Estación de Investigaciones Marinas
Fundacion La Salle, Venezuela

The paper presents the summarized results of six years of fishery exploration off the coasts of Guianas, from Trinidad to the mouth of the river Maroni (French Guiana) and off the north coast of Venezuela, from Cape Codera (10° 35' N 66° W) to the eastern part of the Paria.

The explorations in the Guiana region were carried out by the M.S. La Salle which is a 38 m long stern trawler of 540 tons (B.R.) owned by the La Salle Foundation, and by commercial shrimp trawlers which operate off the east coast of Venezuela.

A total number of 1,431 trawl hauls have been analysed and the results expressed in kg/Ha for each 10 miles square off the northern coast of Venezuela and for each 60 miles square off the Guianas region. This method of representation was chosen in spite of involving several inaccuracies, because it has the advantage of uniforming the results obtained by different types of vessels.

In order to facilitate a better analysis of the results, the general area was subdivided in four sub-areas which are considered different in their ecological features and faunistic structure.

Sub-area 1 - Anzoategui

429 hauls have been analysed. The most abundant species is Diapterus rhombeus (Caitipa) and the most important ones from a commercial point of view are the shrimps (Penaeus spp.) The yields of the commercial catches fluctuate between 3.45 and 10.30 kg/Ha.

Sub-area 2 - Margarita Costa Firme

629 hauls have been analysed. The most important species are: "coro-coro" (Orthopristis ruber) and "panchito" (Pristipomoides aquilonaris). The latter is more abundant in depths of 30 to 50 fm and on sandy bottoms. The shrimps are not very abundant but their high commercial value justifies, to a large extent, the existence of the commercial fishery. Yields of 5-20 kg/Ha are frequent in this region.

Sub-area 3 - Paria-bocas del Drago

North of Trinidad the typical features are large concentrations of Lamparosa (Vomer setapinnis) which attain yields up to 1,000 kilos per hour of trawling. 46 hauls from this sub-area have provided an average figure of 15,90 kg/Ha of commercial yield.

Sub-area 4 - Guianas

300 trawl hauls have been analysed. The type of fishery is clearly different from those of the preceding regions. The most important species are "corvina" (Cynosion virescens) and "roncador" (Micropogon furnierei).

Conclusions

1. Sub-area Anzoategui and Margarita tierra firme.

The number of commercially valuable species contained in every haul is quite high, and none of them predominates clearly over the others. In the area of the "coro-coro" this species, which is the most abundant, represents only 36% of the catch considered by us as "commercial". Serious difficulties are envisaged in the event that fishery regulation measures are established in this area. In such a case it will be necessary to take into account life history, mean sizes, growth, fecundity, etc. of numerous species to select adequate criteria concerning closed areas or seasons and minimum mesh size.

The largest portion of the commercial yield is contributed by the shrimps, but the catches of this resource would not justify - at least in the light of the trawl data analysed so far - to characterize the area as a shrimp ground. Intensive fishing with small mesh size nets might, however, alter the present ecological equilibrium, by reducing the number of fish and favouring a lower trophic level in which shrimps (amongst other species) are represented.

2. Sub-area of Guiana

The fisheries of the Guiana region show features different from those of the preceding areas. there is a smaller number of commercially important species and on the "white fish" grounds, mainly "corvina", and in a far lower proportion, "roncador" predominate.

Any future regulation of the fishery should hence be based on the biological features of "corvina" on the fishery grounds where this species predominates.

No. 4.44

Fishery resources on the northeast coast of South America

by

Melquíades Pinto Paiva
Estação de Biologia Marinha
Universidade Federal
do Ceará

and

Fernando Cervigón
Estación de Investigaciones Marinas
Fundación La Salle
Isla Margarita

The fishing area of the northeast of South America is understood as - from the Cape São Roque (Brazil) to the Gulf of Paria and Trinidad. As a whole, it may be considered as a single ecological unit. Here it is divided into three regions: northeast Brazil, from the Cape São Roque to the mouth of Parnaiba River; north Brazil, from the mouth of Parnaíba River to the Cape Orange; Guianas, from the Cape Orange to the Gulf of Paria and Trinidad.

Although the general hydrography of the area is known, very little information is available on phenomena that could influence the abundance of fishery resources.

Fisheries in the northeast of South America are underexploited, but for the yellowfin tuna and, in the region northeast Brazil, the spiny lobsters. Modern fishing methods have only been applied for the exploitation of spiny lobsters, red snapper, shrimps and corvina.

Species of commercial value and their exploitation are discussed for each region, and an increase in the production of the following fishing resources may be expected: northeast Brazil - tunas, snappers, flying fishes, mackerels, sharks, sardines, spiny lobsters, octopuses, squids, and algae; north Brazil - catfishes, mullets, weakfishes, Atlantic croaker, sharks, rays, snappers, shrimps, and mussels; Guianas - catfishes, mullets, weakfishes, Atlantic croaker, sharks, rays, mackerels, snappers, sea basses, small clupeiformes, shrimps, and squids.

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